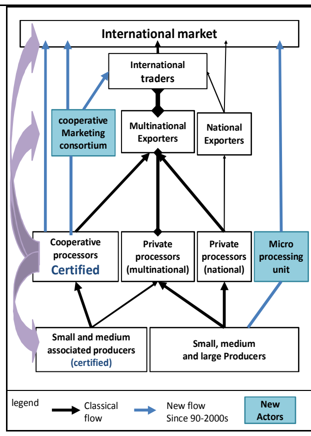
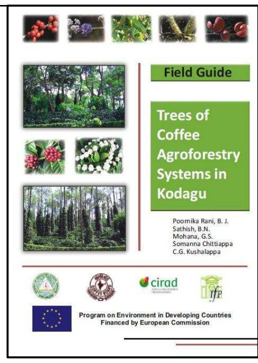
CAFNET

FINAL NARRATIVE REPORT

ENV/2006/114-382

January 2007 to September 2011





CAFNET: Connecting, enhancing and sustaining environmental services and market values of coffee agroforestry in Central America, East Africa and India.

Dr. Philippe Vaast (CIRAD), Coordinator

FINAL NARRATIVE REPORT

CAFNET: Connecting, enhancing and sustaining environmental services and market values of coffee agroforestry in Central America, East Africa and India.

ENV/2006/114-382

January 2007 to September 2011

1. Description

1.1. Name of beneficiary of grant contract:

Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France (CIRAD).

1.2. Name and title of the Contact person :

Dr. Philippe Vaast (philippe.vaast@cirad.fr)

1.3. Name of partners in the Action:

In Europe: University of Wales, Bangor (UWB), United Kingdom.
In Central America: Tropical Agricultural Centre for Research and Higher Education (CATIE), Costa Rica.
In East Africa: World Agroforestry Centre (ICRAF), Kenya.
In India: University of Agricultural Sciences of Bangalore (UASB); Coffee Board of India (CBI); French Institute of Pondicherry (FIP).

1.4. Title of the Action:

CAFNET: Connecting, enhancing and sustaining environmental services and market values of coffee agroforestry in Central America, East Africa and India

1.5. Contract number:

ENV/2006/114-382

1.6. Start date and end date of the reporting period:

January 2007 to September 2011

1.7. Target country(ies) or region(s):

In Central America:
- Costa Rica, watershed of Turrialba,
- Nicaragua, watershed of Peñas Blancas,
- Guatemala, watershed of Rio Hato, region of Las Minas.

In East Africa:
- Kenya, the Southern belt of Mount Kenya,
- Uganda, Lake Victoria belt, Districts of Mpigi and Masaka,

- Rwanda, Lake Kivu shore, Western Province.

In India:
- State of Karnataka, Cauvery watershed, district of Kodagu.

1.8. Final beneficiaries &/or target groups[1] (if different) (including numbers of women and men):

In Nicaragua: members of three local coffee cooperatives in the CAFNET pilot zone COOMPROCOM (159 members), CECOCAFEN (99 members in the zone) and Guardianes del Bosque (35 members). Additionally the project has collaborated with some 8 large private farms. **The target group is constituted of about 300 farmers** directly located in the coffee zone of Peñas Blancas or adjoining areas. Furthermore, the project has collaboration with the national association of Coffee Cooperatives of Nicaragua (CAFENICA) and Exporter Atlantic SA (part of the International group ECOM), the largest cooperative and private coffee exporters in the country. Consequently, **up to 10 000 farmers have benefited from the project**.

In Costa Rica: the Association of Organic Producers of Turrialba (APOT) and farmers of the area of Orosi and Pejibaye selling coffee to F. J. Orlich-ECOM are the primary **target group constituting about 200 farmers.** Through collaboration with the Coffee Institute of Costa Rica and the Committee of the Central Volcanic Biological Corridor Talamanca, the Institute of Electricity of Costa Rica, Model Forest Reventazón, Ministry of Environment, the Ecological Group Pejibaye, the Institute of Water of Costa Rica and the University of Costa Rica, **up to 4 500 farmers have benefited from the project in the target region of Turrialba** through workshops and pamphlets distributed to farmers and their organizations. **Outside this target area** through agreement with COOCAFE, which represents 9 cooperatives of coffee in different zones of the country, we have been able to accompany the technicians working with **4 000 families** on coffee management and environmental services. Therefore, **up to 9 000 farmers have benefited from the project.**

In Guatemala: The members of a local coffee cooperative located in the CAFNET pilot zone (ADIPSA) as well as farmers attended by the National Association of Coffee Producers of Guatemala (ANACAFE) and the NGO "Fundación Defensores de la Naturaleza" (FDN) form t**he target group constituted of about 250 coffee farmers** that are living inside the watershed of the River El Hato. **Up to 3 000 coffee farmers** have benefited from the project in the region, through expansion of CAFNET workshops and trainings to different groups outside the watershed with the partners ANACAFE and FDN.

In Uganda: Farmers' groups of the National Union of Coffee Agrobusiness and Farm Enterprises (NUCAFE) in the Districts of Mpigi and Masaka constituted t**he target group of about 1,000 farmers**. Through collaboration with the NUCAFE and the Coffee Research Institute of Uganda (COREF), **more than 25 000 coffee farmers** have also benefited from the project in the region via dissemination products such as pamphlets on "best practices for coffee agroforestry" and recommendations and information regarding eco-labels.

In Rwanda: **the target group was constituted of 2 500 registered members** of the « Coopérative pour la Promotion des Activités Café » (COOPAC), but this cooperative drains production from the 2 Districts of Rubavu and Rutsiro and **15 000 farmers that have benefited** from the project through dissemination of training materiel on coffee agroforestry practices and eco-labels.

[1] "Target groups" are the groups/entities who will be directly positively affected by the project at the Project Purpose level, and "final beneficiaries" are those who will benefit from the project in the long term at the level of the society or sector at large.

In Kenya: with the partnership initiated during the second year of the project with the MUGAMA Cooperative Union located on the Aberdare side of the Central Province of the country, **the target group was constituted of over 10 000** out of the **140 000 registered members of 154 cooperatives** that are part of this union of cooperatives and have also benefited from the project in the region via dissemination products (best practices & eco-labels) and revival of nurseries.

In India: farmers of the Kodagu Planters Association and Kodagu Coffee Growers Cooperative Society, Madikeri. **The target group was constituted of around 3 000 farmers** from the 38 villages selected in the Cauvery watershed. The final beneficiaries are estimated **at around 20 000 producers** located in the 3 watersheds of the Kodagu district. Through regular workshops over the course of the project and especially during the final one, many farmers in the adjacent coffee producing districts of the Western Ghats (particularly in the state of Karnataka and to lesser extent the states of Kerala & Tamil Nadu) have been sensitized to the main outcomes of the CAFNET project.

1.9. Country (ies) in which the activities take place (if different from 1.7):
Id 1.7

2. Assessment of implementation of Action activities

2.1. Activities and results

Activity Package 1:
The activities consisted mainly in involving actively the steering committees and local stakeholders in the project through periodic meetings and informal discussions.

Activity 1.1. Identification of watersheds and target communities

This particular activity took place during the first semester of 2007 and no major development was needed thereafter during the project. This identification/selection of target watersheds was facilitated by the facts that geographical and social information was easily available in the 3 sub-continents and 7 countries (see geographic details of the various target areas in the Regional reports).

Activity 1.2. Creation and periodic consultations of multi-sector steering committees

The steering committees were constituted in all 7 pilot zones with a large range of stakeholders during the second semester of 2007. In the 3 sub-continents and 7 countries/watersheds, all the stakeholders have been enthusiastic about participating in these committees (see lists detailing the members of these committees in the Regional reports). No major changes in the constitution of these committees were needed during the project period as working relationships were good between the various stakeholders in the 7 target watersheds.

These committees met in working sessions 1 to 3 times per year depending on need and availability of the members. Clearly, these committees have had a very important role over the course of the project in participating to the definition of activity priorities at its onset and in giving to CAFNET teams their feedback following presentations of field work results and drafts of recommendations (see details in regional final reports as well as interim reports of the 3 previous periods).

Activity Package 2:

Activity 2.1. Documentation of traditional agroforestry knowledge and values of native trees

The University of Wales at Bangor, UK, and particularly Dr. Fergus Sinclair, has led this activity in all 7 pilot zones. During the course of the project, they have provided extensive training to local researchers and students and supported them during the analyses of the traditional knowledge gathered mostly during the first 3 years. Farmers and other stakeholders have been very enthusiastic about this activity, valuing very much that researchers were interesting on documenting their knowledge on many issues from trees, their uses and their utility/provision in terms of environmental services. Up to 12 databases have been developed on the AKT software (see details in UWB report in Annexes). This activity has helped greatly in the definition of best practice guidelines. It has resulted in the development of a decision support tool (Caftree) for selection of trees that has been tested in the context of East Africa (see details in UWB report in Annexes).

No major problems were encountered in the recollection of AK during the course of the project with field data collection phase of this AK documentation in all the 3 regions and 7 countries. During the last year, work focused on merging data bases and analysing data. The analysis is providing a strong basis for 1) ranking native and exotic tree species according to farmers' perception in terms of attributes (fuelwood, timber, ornamental, medicinal,...) and contribution to environmental services at the farm (soil fertility, shade provision, carbon sequestration..) and landscape levels (water, biodiversity, ..) and 2) developing management guidelines (Activity 2.4) with the CAFNET team taking great care in incorporating local knowledge in the definition of "best practices" and in the selection of locally adapted tree species combinations for sustainable management of coffee systems.

Documents in the forms of scientific articles, booklets to farmers in local languages have been produced in the 3 regions to recapitulate the information on phenology (flowering, fruiting, leaf fall, etc..), taxonomic status, uses, propagation methods and environmental benefits with the help of images to identify the various tree species (see details in Regional Reports and UW Bangor Report in Annexes).

Over 500 farmers and stakeholders of the coffee and wood value chains were interviewed during the CAFNET project. Ten graduate students (9 Masters and 1 PhD) have helped in documenting these results with the financial help from CAFNET funds and under the supervision of the teams of researchers on the 3 continents.

Activity 2.2. Biodiversity inventories in coffee agroforestry landscapes

Most of the work on biodiversity assessment of coffee agroforestry systems (AFS) and farms was performed during the first 3 years in all 7 target zones.

- In the Kodagu region of India, 500 transects were laid out to assess tree diversity in the watershed during the 1st period; this tree assessment showed that coffee AFS of India are probably the most species- rich coffee systems on the planet and among the most diverse of the agricultural ones. A sub-sample (~120) was used thereafter to monitor intensively epiphytes, bees, birds, small mammals a large scale in coffee AFS that probably among the most highly diverse cultivated systems in the world. Results indicated that coffee AFS predominantly constituted of native trees had the highest biodiversity (tree species, epiphytes & mammals). The surrounding landscape composition (i.e. presence of remnant forests or paddy fields) strongly affects diversity and abundance for birds and bees.

- In Kenya, Rwanda and Uganda, studies on tree species diversity in coffee farms have provided a good understanding of the arrangement of trees in coffee farms and on the reasons for predominance of some exotic species over native species in the coffee landscapes. Clearly increasing population pressure and fragmentation upon inheritance and the need for fuelwood (for domestic consumption and sale in the nearby towns) are the major reasons for the predominance of fast growing exotic tree species such as Eucalyptus and Grevillea.

- In Central America, CATIE and associate institutions of Costa Rica, Nicaragua and Guatemala have assessed tree species, mammal and bird biodiversity in coffee landscapes. In collaboration with the "Citizen Science Program", CAFNET has also conducted workshops to train local stakeholders on basic bird identification techniques as well as participatory bird monitoring. The studies have confirmed the role of coffee agroforests in biodiversity conservation, particular for avian biodiversity, but less so for mammal species. Migratory bird species overwhelmingly prefer coffee agroforests for overwintering habitats, with more than twice as many individuals found in coffee compared to any of the other sites including forest. On the other hand, species of greatest conservation concern are rarely utilizing coffee agroforests as a stable habitat.

Presentations of biodiversity results to farmers and local stakeholders have been done periodically in the 3 regions during annual CAFNET workshops (October 2008 in India, August 2009 in Kenya, March to June 2011 during final workshops in the 3 sub-continents). These biodiversity results have also presented internationally at the World Agroforestry Congress in Nairobi, Kenya (August 2009) and the World Coffee Congress in Bali, Indonesia (October 2010).

In 2009, a book was published in Central America to disseminate to the local stakeholders information on plant species encountered in coffee farms documenting their various characteristics and properties (environmental, medicinal,..). A similar book was published on trees encountered in coffee systems of the Kodagu district of India and distributed to farmers during the final workshop. In India, information sheets with specific tree data pertaining to their farms where also handed out to farmers where surveys were undertaken. In East Africa, results were disseminated in the forms of short reports and newsletters to farmers' organizations (see details in Regional Reports).

Activity 2.3. Environmental impact assessment of coffee agroforests

As pointed out in previous interim narrative reports, local consultations of stakeholders and discussions with the steering committees during the initial periods (2007-08) in all the 7 pilot zones of the 3 regions, have helped greatly in identifying the most important services for local communities that needed to be documented; clearly the most relevant ones locally were water provision, soil fertility, biodiversity conservation and internationally carbon sequestration. Numerous studies on these environmental impact assessments were preformed during the course of the CAFNET project, particularly during the 2nd and 3rd periods. They have provided a sound scientific basis to help in: 1) definition of "best agroforestry practices"; 2) refinement of criteria of eco-labels and 3) to sensitize to the local stakeholders and policy makers on the important role of coffee agroforestry landscapes in the term of provision of valuable environmental services.

- In Kenya, Rwanda and Uganda, participatory surveys with farmers on trees in coffee fields and landscapes have highlighted their important role in terms of provision of environmental services (soil fertility, incidence of pests and diseases) and products (fuel wood, timber, fruits, fibres, medicinal and other non-timber products). In-depth studies on carbon assessment also took place during the last period (2010-11) demonstrating that coffee AFS have the highest potential in terms of carbon sequestration (above and belowground) compared to other cropping systems.

- In the Kodagu region of India, historical data (for some sites up to 50 years) on rainfall patterns were gathered in more than 80 farms as well as data from public and private institutions. They have helped us document the changes in rainfall pattern and distribution over time along the watershed due to changes in forest and coffee cover. For 2 consecutive years, a large study was undertaken to evaluate the water service provided by coffee AFS in terms of water recharge by coffee shaded predominantly native species in comparison to coffee shaded predominantly with exotic species (i.e. *Grevillea robusta*). Contrary to what was anticipated, data collected on 6 farms in an East-West transect along the Cauvery watershed covering a range of annual rainfall from 5000 to 1200 mm showed that the exotic tree did not affect greatly water recharge. Data on biomass and soil carbon have also been gathered in forest remnants and various coffee agroforestry systems to assess carbon sequestration of these coffee systems in comparison to forest. Results show that Arabica coffee AFS with predominantly native species sequestered similar carbon amount as adjacent forest. On the other hand, Robusta AFS with predominantly exotic species (primarily *Grevillea robusta*) sequestered far less carbon than coffee AFS with native species and adjacent forest. Work on bees has also showed the importance of irrigation practices and rainfall on coffee flower pollination and subsequent production.

- In Central America, researchers from CATIE, CIRAD and associate institutions have enhanced our understanding of the role of coffee AFS in water dynamics, sediment transport and carbon sequestration. In Costa Rica, the *"Coffee-Flux"* study site is certainly unique in the "coffee world" using the latest technique of Eddy Covariance to monitor water and carbon fluxes at the whole coffee system level in the largest coffee plantation certified by Rainforest in the country with the collaboration of the Costa Rican Institute of Electricity; 2 scientific articles have already been published in international journals. Work on carbon sequestration and water conservation, comparing certified (Rainforest Alliance or Café Practices of Starbucks) and uncertified farms, was also undertaken in Costa Rica, Nicaragua and Guatemala. Results demonstrated the beneficial effects of shade trees on the provision of these environmental services.

In 2 regions (particularly in East Africa and to a lesser extent in Central America), pests and diseases are threatening the sustainability and economic viability of coffee farms. During the last 2 years of the project, a large effort has been undertaken to assess the effects of agricultural management, shade level and tree composition on the major pests and diseases while taking into account the farm and landscape environment:

- In Central America, studies focused on the effects of shade, agricultural management and landscape mosaic on the incidence of coffee leaf rust (*Hemileia vastatrix*), white thread-blight (*Ceratobasidium stevensii, sin: Corticium koleroga*), coffee berry borer (*Hypothenemus hampei*) and the root-knot nematode (*Meloidogyne exigua*). These studies showed that leaf rust and coffee borer tend to have higher incidence in shade due to buffered micro-climatic conditions favourable to their development.

- In East Africa, studies focused on the effects of tree arrangement, shade level, coffee cultivars and management on the coffee wilt disease caused by *Fusarium xylarioides* and on the various strategies that farmers adopt to cope with this devastating disease. Contrary to Central America, shade trees had either no effect or reduced incidence of pests and diseases depending on the context (Robusta vs Arabica, and altitudinal range).

Contrary to the common belief (and sometimes the “technical messages” from local agricultural extension services), most of the CAFNET results have pointed out towards an absence of effect or even a beneficial effect of shade trees in decreasing the propagation and the incidence of these pests and diseases (except in Central America). On the other hand, all the studies have comforted the fact that tree presence in coffee AFS are highly beneficial to coffee soil fertility. During the course of this activity, methodologies and indicators to document and assess these environmental impacts and services provided by coffee AFS have been developed. Therefore, the CAFNET results have proved to be very useful to 1) evaluate the tradeoffs between maintaining coffee productivity (and hence economic profitability) and enhancing the environmental services provided by coffee agroforestry systems (via an increase in tree species and densities), 2) to provide information to promoters of eco-labels in order to refine their certification criteria, and 3) to develop recommendations for pilot schemes on payment for these environmental services.

Results from these studies on biodiversity, carbon, water, and soil fertility have been periodically disseminated to farmers, particularly individual farmers and cooperatives that wanted to become eco-certified. This diffusion of environmental data by the CAFNET project to farmers, originating from their own farms or ecological zone, has been extremely appreciated at the time of the farm documentation for the eco-certification audit.
Internationally (World Agroforestry Congress in Nairobi, Kenya, August 2009 and World Coffee Congress in Bali, Indonesia, October 2010), the CAFNET team has contributed greatly to publicize and raise awareness on the importance of coffee AFS in providing a large range of environmental services.
Twelve graduate students (10 Masters and 2 PhD) have helped in documenting these results with the financial help from CAFNET funds and under the supervision of the teams of researchers and coffee experts in the 3 continents.

Activity 2.4. Participatory development and pilot testing of sustainable agroforestry management guidelines

In India, work on the participatory definition of “best agroforestry practices” and selection of adequate native species to be associated with coffee has been an on-going process since 2009 on 120 pilot farms from a group of 38 villages comprising farms of all sizes (small, medium and large). Despite the strong interest of farmers to maintain or replant native tree species, workshops and “Role playing games” sessions with farmers have shown that the exotic tree species, *Grevillea robusta*, is the preferred one at the time of tree replanting due to the fact that 1) it is a fast-growing tree (faster than most native species) producing timber in less than 20 years without legal constraints on tree ownership rights and 2) this exotic species is a good living stand for the production of pepper which helps in the revenue diversification of farmers.

- In 2010-11, CAFNET run a series of 4 workshops with farmers and other stakeholders based on a participatory modelling approach (called “Companion modelling”), which is based on Role Playing Games (RPG) and Agent Based Models (ABM) to elicit farmers’ strategies and validate the drivers behind tree management decisions. These RPG workshops have served as discussion platforms between stakeholders and policy makers, while ABM helped explore alternative scenarios and possible long term impacts at the landscape level. The results of these sessions confirmed what is currently observed on the ground, i.e. a long term interest of farmers in increasing the percentage of *Grevillea robusta* at the expense of native species all over the landscape level, regardless of the land tenure and proposed policy changes for tree rights identified during the discussions with stakeholders. This approach confirms the need for 1) developing a scheme for direct or indirect payment to conserve native species and 2) identifying fast growing and economically valuable native species to substitute for the economic buffer currently provided by this exotic species.

- A study on a network of farms was undertaken during the second half of the project to identify fast growing native species via a continuous monitoring of tree growth rates (via steel dendrometer bands affixed to 345 trees) of 5 species (4 native species, and the main exotic one *Grevillea robusta*). Results show that a few native species have comparable growth rate to *Grevillea robusta* and hence have been advised to farmers as potential alternatives to the exotic species.
- A book, presenting the characteristics, main uses and services according to farmers' knowledge of over 200 tree species encountered in coffee landscapes has been published and disseminated to coffee communities during the last months of CAFNET.

In East Africa (particularly in Kenya and Rwanda), farmers are mostly associating trees at the periphery of their coffee plots and rarely into the plots amongst coffee plants as they were advised to do so by extension services of coffee institutions and rural development agencies for the past decades. In these countries, there is still a lack of consensus on the beneficial effects of shade trees on coffee production and cup quality and on the incidence of pests and diseases. Consequently, CAFNET work mostly consisted in 1) gathering knowledge from farmers that traditionally manage shade trees in association with coffee and 2) studying coffee and shade tree interactions in formal trials (Uganda) or in a network of farmers' fields (Kenya and Rwanda). Over the course of the CAFNET project, a large effort has been undertaken to collect information on native species and to have farmers rank them according to their own perception in terms of utilities (soil fertility, shade, timber or fuel wood, other products, pest and diseases, water, ..etc). Collated ranked data were combined with farmers' assessment of tree phenology and scientific information to develop the pilot CAFTREE decision support tool. This tool provides guidelines for selection of trees and tree combinations within coffee farms to meet different sets of production and sustainability objectives, customised for different local ecological and socio-economic contexts. This represents a breakthrough in moving away from selecting a few 'best bet' species, towards supporting the maintenance of a diversity of tree species on coffee plots and marshalling the information that is needed to promote the trees (e.g. propagation or pruning management protocols) where it is needed (See final report of UW Bangor for more details in Annexes). Participatory workshops have also been organized with local organizations to sensitize farmers on the benefits of agroforestry practices and to encourage them to increase tree diversity and abundance on their coffee farms. In view on the scarce scientific knowledge of tree associated with coffee in East Africa, several trials were initiated during the 1st period and maintained until the end of the project:

- In Rwanda since 2008, on assessing the influence of tree shade on coffee productivity and cup quality below the canopy of trees of 11 species with results showing beneficial effects of shade provided by associated trees.
- In Uganda since 2008, on quantifying the impact of shade on coffee yield, coffee tree vigour, coffee quality, incidence of insect pests and disease attacks, as well as soil fertility by COREC, ICRAF/CIRAD and NUCAFE with results also showing beneficial effects of tree shade on these major issues.
- In Kenya, on two experimental stations of CRF and a network of farm trials with the MUGAMA Coffee Coop Union, on coffee production and quality and incidence of pests and diseases with results also showing beneficial effects of tree shade on these major issues.

On top of documenting scientific information on biophysical interactions of shade trees and coffee (soil fertility, control of pests and diseases, coffee productivity…), these trials also served as demonstration plots for farmers' workshops. It is unfortunate that the local institutions will not have the financial means, once the CAFNET project is over, to maintain these study sites for both research and extension purposes. In Rwanda, Uganda and Kenya, CAFNET also supported the revival or the development of tree nurseries by training staff of these nurseries and giving them seeds of target tree species from ICRAF seed bank (see more details in the final narrative report of East Africa in Annexes).

In Central America, the validation of agroforestry sustainable practices was undertaken on management trials set by the CAFNET team in pilot farms of the 3 target watersheds on a range of farms certified by various certification schemes (Starbucks, Rainforest, Organic or UTZ Certified). The participatory development and testing of these sustainable coffee agroforestry management guidelines have been done directly in farmers' fields. Validation and dissemination of these "best practices" have been undertaken in the 3 countries through workshops on pilot sites in collaboration with local partner organizations (see details in Central American report in Annexes). The main topics addressed during these field workshops were:

- Shade regulation along the coffee production cycle to balance light penetration and nutrient contribution via matter organic biomass addition;
- Diversification of shade tree composition to enhance tree products and environmental services;
- Alternative to chemical fertilizers for coffee plantations (particularly production and application of organic fertilizer);
- Selective management of natural soil cover to limit runoff and soil erosion;
- Pruning of coffee plants for vegetative rejuvenation;
- Monitoring of pests and diseases in relation to shade level.

The results of AP2 "Participatory documentation of functional roles of trees and environmental benefits of coffee agroforestry practices" have exceeded the expectation of the CAFNET team due to the facts that farmers and their organizations have actively participated in the documentation and pilot testing phases. We have registered many interesting feedbacks from participants on the various agricultural practices tested on the demonstration plots and pilot farms. Adoption rate of the "best practices" has been very high, particularly in Central America.
Active involvement of farmers has allowed CAFNET to develop valuable databases on trees in coffee agroforestry systems in all pilot zones as well as databases on knowledge about tree ecological, economic, social and cultural roles.
Through workshops and also sessions on role playing games with farmers (only in India), we have a better understanding of the economic and social reasons why farmers maintain or not trees (especially native species) on their farms.
Clearly, there are still many aspects on the role of trees to be documented at the end of CAFNET and pilot testing of "best practices" needs more than 1-2 years to be completed and mass-adoption of these "best practices" ever more. Therefore, it is the hope of the CAFNET team that local organizations (either public agricultural extension institutions or farmers' organizations by themselves) will be able to continue in that vein with financial means far more limited than during the project.

Activity Package 3:

Activity 3.1. Valuation of environmental services

The economic valuation of environmental services provided by coffee AFS and landscapes was undertaken from various angles through 1) cost/benefit analyses of maintaining or enhancing shade level (and hence carbon sequestration and other environmental services) in coffee farms, 2) studies on cost-benefit analyses of certification schemes and 3) studies of existing pilot schemes (mainly in Costa Rica) for direct payment of environmental services.

This activity was mostly concentrated in all pilot zones during the last period of the project in large part due to the fact that the collection of field data characterizing farms and quantifying environmental impacts and services took a lot of time and effort during the first 3 years of the CAFNET project (see AP2).

- Payment for environmental services (PES).

In Costa Rica where pilot projects on PES in the coffee sector are already implemented and where there is a political will to upscale these PES schemes at the national level, CAFNET has been actively involved in the development of a national scheme through forums and discussions with stakeholders of the coffee sector and political authorities (see details in Central American report). In late 2009, the development of PES proposal has being shared with potential financiers of the Voluntary Carbon Scheme. The CAFNET team has also shared this Costa Rican experience with other coffee producing countries of Central America and beyond in India and East Africa through presentations during annual and final workshops. The recommendations from the platform formed by representatives of FUNCAFOR (a group of cooperatives of COOCAFE), CAFNET, INTA (National Institute on agricultural technology), ICAFE (Coffee Institute of Costa Rica) FONAFIFO (the Forest Financial Fund of Costa Rica) and two ministries (of Environment and of Agriculture) has led the government of Costa Rica to create a new pilot scheme specifically dedicated to the payment of environmental services provided by coffee agroforestry systems in June 2011.

In India, following economic and biodiversity surveys undertaken in 115 reference farms during the 1st and 2nd periods, an economic valuation of carbon sequestration was undertaken in 2010-2011. A scientific report evaluated the tradeoffs between maintaining or increasing the tree cover in coffee plantations to enhance carbon sequestration and the production of coffee and pepper (a scientific paper will be submitted on this matter by the end of 2011). Results have been presented to local stakeholders and policy makers. However, there is currently no institution (cooperatives, NGO or governmental institutions) in the region capable of implementing a program such as REDD (Reduction of Emissions from Deforestation and forest Degradation). Therefore, carbon payment will have to be bundled with other direct or indirect payment (eco-certification) for other environmental services (water, biodiversity, scenic beauty) to become an effective strategy to conserve the native tree species-rich coffee agroforests of this region.

In East Africa, the concept of “payment for environmental services” is rather new, except perhaps for carbon sequestration. Consequently, no pilot schemes were in implementation in the target zones during the time of the CAFNET project. Therefore, the CAFNET team has concentrated its effort in presenting the results and experience of Central America to East African countries in workshops and particularly the annual workshop in Kenya (August 2009) where many cooperative representatives were eager to obtain as much information possible from Central American researchers.

- Cost-benefit analyses of certification schemes

In Central America (particularly in Costa Rica), a large number of farmers (> 40 000 for the entire region) are already eco-certified (~30% Fair Trade, ~20% CAFE Practices of Starbucks and ~10% Rainforest Alliance). In view of the strong interest from funding agencies, NGOs, governments and farmers in learning on the economical and ecological impacts of these eco-certifications at the farm level, CAFNET has undertaken a large scale study in Nicaragua (298 surveys), Costa Rica (240 surveys) and Guatemala (170), testing the impact of the 5 major coffee eco-labels (Organic, Fair Trade, CAFÉ Practices, Rainforest and UTZ certified) through a survey methodology developed by the COSA project in order to allow comparability between CAFNET results in Central America with other studies undertaken by COSA in Colombia, Brazil, Vietnam and Tanzania. Results have been presented to farmers’ cooperatives and promoters of coffee eco-labels as well as governmental representatives; they showed that financial rewards to farmers are far from negligible (although not always as high as farmers were expecting especially when coffee prices are high) and these eco-labels serve as a strategy to secure access to markets of “specialty coffee” at the medium term and to insure them against coffee price volatility. They also showed that organic certified coffee was the least profitable of certified coffees due to low productivity.

In East Africa, the introduction of coffee labels is more recent than in Central America, and far less farmers are certified. Nonetheless, there is also a strong demand from farmers, cooperatives and local authorities regarding the specific criteria of the various coffee eco-labels and their impact on the livelihoods of farmers’ communities. To those effects, a series of studies was undertaken in 2009-2010 in Rwanda and Kenya comparing the criteria of these labels and their economic impacts at the farm level. Results from this comparative study have been presented to local stakeholders (see details in the East African report). An exchange of results and experience between Central America and East African countries was also done through CAFNET annual workshop in Kenya (August 2009) where many cooperative representatives express their interest in gaining information from the experience of other regions.

In India, penetration of eco-labels is limited to a few industrial groups well structured and integrated from coffee production to commercialization. Less than 3% of the Indian production area is eco-certified (UTZ or Rainforest) and less than 0.5% as organic coffee. In view of the interest of part of the coffee community (i.e. medium and large farmers), the CAFNET team in India has organized over the course of the project a series of information workshops towards farmers on the various criteria of these labels to stimulate farmers’ engagement into this process. Through these communication efforts in 2009, one group of small-medium farmers became certified in 2010 for Rainforest and UTZ in collaboration with 2 large traders (Ned Commodities and Ecom-Gill) interested in promoting coffee eco-certification. These farmers have received a net premium for the harvest 2009-2010 in the range of 5-10% of the farm gate price as traders supported the cost of eco-certification. From the certification process with this farmers’ group, it appears that farmers meet rather easily the ecological criteria of the various eco-labels, but some have difficulties to meet administrative criteria such as bookkeeping and social criteria such as minimum wage, leaving conditions of permanent and/or temporary workers, sanitary protection of workers during chemical handling. During the last 18 months of the project, the CAFNET team organized over a dozen workshops at village level during the last project period with the participation of pioneer farmers certified in 2009-2010 to share their experience with other farmers and to stimulate the involvement of other farmers’ communities of the region in the eco-certification process. This has resulted in the formation of 7 additional groups of farmers (73 in total) that entered the certification process for the 2010-11 coffee crop with the help of the CAFNET team to face the challenges of meeting administrative and social criteria of the 2 eco-labels (Rainforest and UTZ) promoted so far in the region. One the collateral results of the certification process is the fact that farmers in the process of being certified took more care to coffee processing and ended up receiving premiums for quality that were often higher than the one received for eco-certification itself. Due to the lobbying of CAFNET India in conjunction to farmers’ unions and local stakeholders and the Coffee Board of India, the government of India took the decision in late 2010 to subsidize 75% of the certification cost which has been a major limitation for farmers willing to get eco-certified. Although the number of farmers entering in the certification process is rather low, their positive experience has raised a lot of interests by farmers and being highly publicized in the local press.

Activity 3.2. Development of model value chains through assessment of farmers' economic constraints and building of producer-trader alliances

In East Africa and India, studies on value chains took place during the 1st and 2nd periods. The main results have been highlighted in previous reports (with summaries in the final reports of East Africa & India in Annexes). During the final period of the project, CAFNET teams in these 2 regions have been presenting the main findings and given recommendations to local stakeholders (from funding agencies to NGOs, governmental agencies and farmers' communities) on how to enhance the share of coffee value towards farmers. These results were also presented at the 2nd World Agroforestry Congress, Nairobi (August 2009) and the World Coffee Congress in Bali in October 2010.

In Central America, an analysis of coffee commodity chain was carried out during the last period in the 3 countries (see details in the final report for Central America in Annexes) to analyze the structure and functioning of the commodity chain at national level. The strategy of commodity chain stakeholders in terms of alliance was also described. The strategy of farmers' organizations with respect to certification was also analyzed. Certification appears as one of the main strategies to secure market access to small farmers, and consortium building among cooperatives as a way to counterbalance power of multinational exporters. In the 3 countries, the CAFNET team has presented the main results on market and value chain to representatives of cooperatives and federations of cooperatives and given their recommendations. A specific study was also undertaken regionally to investigate the reasons for the decline in organic coffee production in Central America and feedback information was given back to farmers' organizations via workshops organized in late 2010 at the local or regional levels.
An article comparing and contrasting the coffee value chains of Kenya and Costa Rica was presented at the the World Coffee Congress in Bali in October 2010.

Activity 3.3. Assessment of farmers' legal constraints to adoption of agroforestry practices

Studies on these issues took place during the first 2 years in the 3 regions and results have been highlighted in previous interim narrative reports. During the last period, recommendations have been given to local authorities in local forums or via technical advices during workshops organized by the various ministries or governmental agencies.
CAFNET has participated as technical advisor in four meetings in Nicaragua organized by the Protected Areas Department of the Ministry of Environment to develop a joint management plan for the Peñas Blancas Natural Reserve. Participation of the CAFNET team has also taken place in Costa Rica and Guatemala (see details in the Central American Interim report for Period 3).
In East Africa, feedbacks have been given to farmers' organizations as well as technical recommendations to government agencies in charge of coffee, agriculture and forestry with respect to the impact of current public policies and legal aspects for the promotion of coffee management practices.
In India, the CAFNET team published an article on this issue in an international scientific journal in 2011 and has exposed to local stakeholders, farmers' unions and governmental authorities these pressing issues on tree diversity conservation and possible remedies. This has materialized through changes in the 'Forest Laws' (giving more rights to farmers in the commercialization of native timber trees) undertaken by the state authorities of Karnataka in 2010.

Many important achievements have been recorded for this AP3. Studies on value chains in all 7 countries have allowed the CAFNET teams and more importantly local stakeholders to assess farmers' constraints in terms of coffee commercialization. The assessment of farmers' legal constraints to adoption of agroforestry practices has also allowed to propose changes in “forest laws” or to propose recommendations to promote diversification in tree species in these coffee farms and landscapes. Through formal workshops and informal discussions, the CAFNET teams have shared their view with a large range of local stakeholders. Overall, these stakeholders, including agricultural and forestry authorities, have taken into account many of CAFNET recommendations to review the current forest laws and specifically promote agroforestry in the 3 regions.

In the 3 regions, the CAFNET teams have contributed greatly to the main goal of this AP3 which is “building producer-trader alliances” particularly with NGOs and the private sector promoting eco-certification and adoption of agroforestry practices. Technical criteria of some eco-certification schemes (Rainforest, UTZ, Organic) have been critically reviewed and some changes have taken place to make them more adapted to local conditions following recommendations of CAFNET and discussions between farmers and eco-promoters.

Activity Package 4:

Activity 4.1. Development and/or refining of GIS tools for up-scaling

During the first and second periods of the project, geographic information systems (GIS) were developed for all 7 pilot zones and upgraded during the 3rd and period through the acquisition of new satellite images whenever available.

One of the most novel aspect for this activity revolves around the NDVI technology (normalized difference vegetation index) that was tested in Costa Rica to facilitate the monitoring of Ecosystem Services (ES) provided by coffee plantations using stand leaf area (LAI, the leaf area per unit of soil area) as an integrated indicator of several ES (yield, C sequestration, water balance partitioning, erosion protection, etc.). Results were very encouraging and could certainly cut down tremendously the verification cost in terms of tree cover and hence carbon sequestration after involvement of farmers in Voluntary Carbon Schemes or REDD and particularly for small farmers where the ground verification of a multiplicity of small coffee areas is time consuming and very costly. This NDVI technique has also been used with some success in India to characterize the various coffee agroforestry systems with respect to forest remnants (see details in Regional reports).

Activity 4.2. Watershed and landscape integration and monitoring of impact

As mentioned in the previous reports, GIS tools have proved to be very useful in 1) retracing landscape dynamics and documenting the connectivity between coffee AF systems and forest patches on farms and reserve forests, 2) helping in the selection of farms and sites where to conduct biodiversity and environmental assessment studies; 3) analysing at the landscape level the results of these studies and 4) developing tools to prioritize areas of high impact for provision of environmental services in these coffee landscapes.

Initiated during the 2nd period, a GIS up-scaling tool has been refined during the last period for the prioritization of “hotspots” in a landscape for payment of environmental services (PES). CAFNET has developed this approach in the Volcanic Central Talamanca Biological Corridor of Costa Rica to target PES schemes on farms where habitat conservation and soil erosion alleviation are critically needed. This approach coupling GIS up-scaling and modeling allows identifying specific areas in the landscape where these services are most critically needed, where agroforestry interventions will have the greatest impact, and where payments should be made in priority. Discussions on these issues have taken place with local authorities and stakeholders of Volcanic Central Talamanca Biological Corridor and ministries (Environment and Agriculture). This experience developed in Costa Rica has been shared with other countries in Central America and presented to partners in East Africa and India.

The preliminaries results were presented at the 2nd World Agroforestry Congress, Nairobi (August 2009).

GIS tools and methodologies developed by CAFNET have greatly helped to take into account the effects of tree arrangement at the farm level (Costa Rica, Kenya and India) and the landscape matrix (Central America, East Africa and India) on the spread of the coffee pests and diseases with results showing that a high proportion of coffee plantations in the landscape could favour the dispersal of coffee berry borer, whereas a high proportion of opened spaces like pastures could facilitate the dispersal by wind of coffee rust.
In India, GIS tools have also been used to upscale local information on rainfall to watershed and regional levels as well as to assess bee pollination effect in the landscape mosaic context.

In the 3 regions, CAFNET has given free access to the GIS tools and methodologies developed within the framework of the project to other institutions working in the target regions.

<u>Activity Package 5</u>:

Particularly during the last 2 years, many efforts have been dedicated to Activity Package 5 to enhance the capacity building of farmers' organisations and for the dissemination of results.

<u>Activity 5.1. Building capacity of organizations to manage sustainable coffee agroforests and to participate effectively in improved marketing of coffee and tree products</u>

As pointed out in the previous reports, the project has achieved some important results such as 1) enhancing local awareness on the importance of coffee systems in preserving biodiversity and providing environmental services, 2) documenting and sensitizing farmers' communities and local authorities to the importance of traditional ecological knowledge, 3) assessing and discussing with the various target groups on their organizational strengths and weaknesses, and 4) identifying and informing target groups on the benefits of the various eco-labels, strategic local partners (NGO or exporters) promoting these eco-labels, and possible strategies of individual farmers of farmers' cooperatives to access these eco-markets.

In Central America where cooperatives have already experience in terms of eco-labeling and marketing their coffee to exporters in country or even internationally, CAFNET has concentrated its effort on capacity building by reviewing strengths and weaknesses of the cooperatives of the target zones through interviews of managers and/or workshops with farmers. CAFNET has also stimulated the dialogue between these cooperatives and NGOs or the private sector promoting coffee eco-labels:

- In Costa Rica, CAFNET has greatly helped in strengthening collaboration between eco-certification NGOs and the private sector (Rainforest, Nespresso, Starbucks, UTZ Certified) to promote a better certification service to farmers' communities. CAFNET has periodically share with them results in terms of valuation of environmental services provided by coffee agroforestry systems with the view to help refine technical criteria of the eco-labels.
- In Nicaragua, CAFNET has actively participated in the learning alliance on rural business development in partnership with many NGOs including CRS, SNV, Oxfam, CARE, Rainforest Alliance. In 2010, this learning alliance organized a series of training modules to strengthen the marketing and business capacity of producers' organizations with the ones of the CAFNET pilot zones fully participating. CAFNET also helped one cooperative to successfully apply for funds to local funding agencies to implement its proposed business plan developed with the help of the CAFNET team.

- In Guatemala: CAFNET in collaboration with ANACAFE organized a series of workshops on agricultural management (shade, soil fertility, pests and diseases), marketing, organization of the local coffee value chain and eco-labelling. CAFNET also organized the visit of a group of mayors from rural areas from Guatemala to Costa Rica to visit farmers' cooperatives and discuss with local authorities on the implementation of pilot and national schemes for payment of environmental services.

CAFNET has also played a central role in a series of workshops across Central America to share conclusions of its analysis of the coffee organic crisis with producers' organizations and to develop policy recommendations for improving support to this organic coffee sector in crisis for the last 5 years.

In East Africa, the main eco-labels are also penetrating the coffee value chains, although less rapidly than in Central America, due to limitations in coffee farmers' organizations. Still, capacity-building of cooperatives has been undertaken through information given to these cooperatives on successful experience on cooperative organization, management and commercialization strategies in the region (i.e. mostly the highly successful example of Coopac in Rwanda) and across continents (i.e. the "Costa Rican model") through workshops and presentations. Over the course of the project, informal discussions have periodically taken place between the CAFNET team and exporters keen to promote eco-labels to strengthen producer-exporter-certification alliances in the region. In Uganda, NUCAFE, one of the associate partners, developed a guide "Farmer Ownership Model" for farmers' organizations to improve coffee quality, value chain building to enhance farmers' market value share, group dynamics for better governance and management of farmers' organizations, and that proposes strategies to access directly exporters and get certified (see details in East African report in Annexes).

In India, the situation was the most challenging as pointed out in previous reports due to the fact that farmers' associations are very few (only 2 officially registered) and with a role limited to lobbying towards governmental authorities. These associations do not actively participate in coffee recollection, processing and commercialization. Indeed, more than 95% of the farmers dry their coffee on farm and sell it at the farm gate to agents of private processing plants, traders or exporters. Still, the Indian CAFNET team has worked hard in all the villages of the Cauvery watershed to promote eco-labelling by 1) organizing numerous meetings with farmers to explain the philosophy and advantages of these eco-labels, 2) inviting large individual farmers and industrial coffee enterprises (such as TATA Coffee and BBTC) already certified to share their experience with small-medium farmers on the certification process, 3) working closely with two international coffee exporters (ECOM-Gill and Ned-Commodities) eager to promote eco-labels, 4) presenting the on-going experiences in Central America and East Africa on coffee eco-labelling and marketing and 5) successfully accompanying the first seven groups of small and medium farmers in getting certified (Rain Forest and UTZ Certified) for the 2009-10 and 2010-2011 coffee harvests.

Activity 5.2. Dissemination of methods and lessons to national and regional actors

During the course of the CAFNET project, 3 international workshops have taken place in Costa Rica (September 2007), India (October 2008) and Kenya (August 2009) as well as 3 final workshops at regional level (for East Africa via videoconference between Nairobi and Kampala in March 2011, for India in April 2011, and for Central America in Costa Rica in June 2011). During these international workshops, over 20 members of the CAFNET teams from Latin America, East Africa, Europe and India have shared their research and development experiences across continents. These workshops were also attended by many farmers, representatives of local authorities and stakeholders of the local coffee value chains.

During these workshops, field visits of cooperatives and coffee farms of their members have given the opportunity to the CAFNET team to present the achievements of the CAFNET project and to conduct interactive discussions with local stakeholders on eco-labels (UTZ Certified, Rainforest Alliance, Starbucks, Organic), management of cooperatives and strategies of commercialization. This has helped to raise the profile of the CAFNET project and local awareness of the beneficial role of coffee agroforestry systems in terms of providers of environmental services, and led to interactive discussions on the role of payment for environmental services and eco-labels in improving livelihoods of coffee communities.

During the course of the project, many local and national meetings (>150) were held in all 7 countries to 1) present the goal and activities of CAFNET, 2) share current knowledge and results on coffee agroforestry systems and their environmental services, 3) identify gaps in research or development activities to be addressed by the CAFNET project, and 4) develop concept notes and proposals for future projects in these regions (see details exposed later in this report). The major events and workshops organized by CAFNET in the 3 regions are presented in the annexes of the final regional reports:

Around 50 local, national or regional events took place in Central America.
Over 60 local or national events took place in India.
Around 50 local, national or regional events took place in East Africa.

Locally or regionally, many dissemination activities have taken place:

- In India, small pamphlets have been distributed to farmers in the predominant local languages (Kannada and English) on biodiversity inventories in coffee farms, coffee quality, soil analyses and economic performances of reference farms. A guide on "best management practices" with recommended native tree species has been handed out to local stakeholders during the final workshop. Two books (on traditional agroforestry and ecological knowledge, and on tree species present in coffee systems) have been published and handed out to farmers and local stakeholders during the final workshop.
- In Uganda, NUCAFE, the local partner, has developed specific information and training products, including a manual and video programs, about sustainable AF practices and coffee commercialisation.
- In Kenya, ICRAF has disseminated information on coffee AF practices through various media supports and particularly via a monthly "CAFNET Newsletter" written in Kikuyu language and disseminated for 22 months to farmers' organizations of the Central Province.
- In Rwanda, CAFNET has contributed to the edition and the translation into Kinya-Rwanda of pamphlets about adequate tree species to be associated to coffee and best AF practices.
- For Central America, a guide has been developed in Spanish for participative training on coffee plantations for sustainable management and environmental services.
- In Costa Rica, a book has been edited and distributed on tree and plant species encountered in coffee farms with mention of their ecological and medicinal properties.
- Guides have been edited in English and Spanish to using CAFNET knowledge bases of India, East Africa and Central America
- CAFTREE, a pilot decision support tool has been developed for promoting tree diversity on coffee farms
- Guidelines were developed for biodiversity and environmental assessments in coffee landscapes
- Geographic information systems have been developed in coffee landscapes of the 7 target regions
- Methodologies have been developed to facilitate the monitoring of ecosystem services of coffee systems

- Reports and powerpoint presentations have been edited to highlight the main features of the coffee value chains in the 7 target countries
- Reports and powerpoint presentations have been edited to highlight the main features and criteria of coffee eco-labels
- Cost/benefit analyses of shade in coffee farms and of certification schemes have been shared with local stakeholders
- Recommendations have been delivered in terms of refinement of social and ecological criteria of coffee eco-labels
- Policy recommendations were developed on tree rights and PES
- Scientific presentations have been published in proceedings of International congresses
- Scientific articles have either been published or submitted to international journals

A total of over 200 documents have been produced during the course of the CAFNET project. The main ones are available online via the CAFNET websites (see below) or CD organized by region with following the categories:

- Handouts, manuals and data sheets distributed to farmers' organizations
- Books published by CAFNET
- Chapters published in international books
- Proceedings of national and international conferences
- Scientific articles published in international journals
- Theses of graduate students
- Clips on CAFNET published in local Newspapers.

In total, more than 70 presentations have done by the members of CAFNET team on the 3 continents on the most relevant results achieved by the project in international forums and national events (see details in regional reports).

In particular, the CAFNET team participated in the following high-profile, international conferences:

- Participation to the Second World Agroforestry Congress, Nairobi (August 2009)

20 members of the CAFNET team participated at the World Congress organized by ICRAF and UNDP at the headquarters of UNDP in Nairobi, Kenya, with a large gathering of over 1200 delegates from over 90 countries.
20 oral communications and posters on CAFNET results and experience in the 3 regions were presented at this congress.

- Participation to the World Forestry Congress, Buenos Aires, Argentina (October 2009)

Dr Sinclair (UW Bangor) presented at this world forestry meeting the importance of trees from agroforestry systems in the rural landscapes.

- Participation to the IUFRO, Seoul, South Korea (August 2010)

CAFNET presented results on local agroforestry knowledge and role of trees in the conservation of biodiversity at this important world forestry congress.

- Participation to the World Coffee Congress, Bali (October 2010)

CAFNET was very much present at this important congress of the world coffee sector in Bali in October 2010. Five members attended this congress and presented 13 oral communications and posters on the results and experience gained from the CAFNET project.

A webpage on CAFNET and its activities in India is periodically updated in English by the French Institute of Pondicherry: http://www.ifpindia.org/Coffee-and-Environmental-Services-in-the-Western-Ghats.html.
A webpage in Spanish has been put on line on the CATIE website (www.catie.ac.cr/cafnet) at the end of 2009 for Central America. In collaboration with the “Citizens Science Program”, a webpage (http://web.catie.ac.cr/pma) is on line for the participatory bird monitoring program where participants can upload their data using internet.
A webpage in English has been put on line on the ICRAF website for East Africa (www.worldagroforestrycentre.org/cafnet).
For the documentation of traditional knowledge, UW Bangor has created a specific webpage (http://akt.bangor.ac.uk/ProjectDownloads.php) where student theses, guidelines for farmers’ interviews and data collection, and databases are freely accessible.

2.2. What is your assessment of the results of the Action? Include observations on the extent to which foreseen specific objective and overall objectives were met and whether the Action has had any unforeseen positive or negative results. (please quantify where possible; refer to Logframe Indicators).

The CAFNET team is very proud of the results achieved over the project duration.
With reference to the logical framework of CAFNET, most if not all the specific goals have been met.
As previously mentioned, the project has considerably **increased the local and international awareness on the importance of coffee agroforestry systems in preserving biodiversity and providing environmental services.** A very large number of scientific studies documenting the most locally relevant impacts and environmental services of coffee AFS have been performed by CAFNET scientists and over 60 graduate students (a large majority from developping countries) with an active participation of local coffee communities. These local stakeholders and particularly farmers have clearly appreciated the bottom-up approach taken by the CAFNET, especially in the documentation of local and traditonal knowledge on tree and agroforestry practices. This has given them the "sentiment" that their view was taken into account and led them to **participate enthousciatically in a large range of CAFNET activities** (documentation of environmental services, participatory developement of best practices, discussion with other stakeholders of coffee value chain, feedback on personal experience on eco-certification,..etc). Participation of local authorities and agencies has also been very strong and constant over the course of the project via steering committees and platforms developped by CAFNET or in which CAFNET partners have participated. **A much higher level of interactions can been observed in the 3 regions between rural coffee communities and local or international stakeholders of the coffee chains and certainly the niche market of eco-friendly coffee** due in part to the actions of CAFNET. Certainly CAFNET has contributed a lot through informal discussions with farmers' organisations and NGOs or exporters keen to promote eco-labels to **the strengthening of the producer-exporter-certification relationships in the 3 regions**.
Via its large amount of scientific works undertaken on biophysical and socio-economical issues, **CAFNET has certainly contribute to build a more scientifically sound basis to review criteria of eco-labels** to make them more effective locally and more attractive to coffee farmers.
Finally, it is fair to emphasize that **CAFNET has proposed constructive recommendations for pilot schemes on payment for environmental services** rather than making full proposition on the development of schemes themselves.
In the 3 final workshops at regional levels, many representatives of farmers' organizations have strongly and publically acknowledged the help provided by the CAFNET team to improving the governance of their organization and access to high value coffee markets.

2.3. What has been the outcome on both the final beneficiaries &/or target group (if different) and the situation in the target country or target region which the Action addressed?

In the 3 regions and the 7 target watersheds, target farmers' groups have been empowered with technical information (via workshops, books and pamphlets distributed to their organizations) and have seen their business skills and access to markets enhanced via information and help provided by the CAFNET teams. Many farmers and their organizations have participated in the pilot testing and to some extent adopted more ecologically sound agroforestry management practices. Sustainable coffee management guidelines have been given to these target groups and final beneficiaries.
CAFNET has also provided to these target groups (and to final beneficiaries) guides on assessing local knowledge and on methodologies for the valuation of environmental impacts and services of coffee agro-ecosystems.
Target groups have also received information on existing certification and sustainable production schemes and recommendations for improving their applicability have being presented to NGOs and the private sector.

Target groups have also received information on coffee value chains and strategies to improve their market value share. Training tools and materials for production and marketing of coffee agroforestry products have been disseminated (e.g. website, manuals, radio programs and local newspaper articles) to these target groups and final beneficiaries in the 3 regions.
CAFNET has contributed to strengthen relationships of target coffee communities with NGOs and traders promoting eco-friendly coffee production. CAFNET has contributed to the introduction of coffee eco-labels for small and medium farmers in the target zone in India. In the other regions (East Africa and Central America), CAFNET has helped farmers' organizations to improve their strategies on coffee marketing, particularly the selection of eco-labels leading to higher financial reward (i.e. premium) towards their members for coffee eco-certification and/or enhanced coffee quality.
Local authorities and governmental agencies have been regularly informed of the CAFNET activities and results as well as sensitized of the key role of coffee agroforestry systems in the sustainable development of coffee communities. Through recommendations by the CAFNET teams in the 3 continents, they have also been sensitized about appropriate changes in policies and institutional support needed to promote farmers' adoption of "best coffee agroforestry practices". Several important recommendations of CAFNET have been put into practices via changes in forest laws or pilot schemes on payment for environmental services.
Technicians of cooperatives and local extension institutions have been trained on sustainable coffee practices and production of tree seedlings in nurseries (East Africa).
Over 60 students have been trained through field research performed within the framework of the CAFNET project.

2.4. Please list all publications (and no. of copies) produced during the Action on whatever format, amongst others containing new approaches, innovative ways of communicating… (please enclose a copy of each item, except if you have already done so in the past).

Theses:
A total of 67 graduate students (55 Masters and 15 PhD) and 7 undergraduate students (with a majority of them originating from target countries) participated in the CAFNET project. By the end of the project, 50 students have defended their theses that are freely available on the websites of partner institutions of the project (please see the list and titles of these theses in the Annexes of the regional reports).

Presentations in international conferences:
75 oral or poster presentations were done by the CAFNET team in international conferences with abstracts or full papers presented in the proceedings of these conferences (please see the list and titles of these presentations in the Annexes of the regional reports).

Scientific articles and book chapters:
11 scientific papers have been published in International journals and it is expected that a minimum of 30 additional ones will be published in the coming years (please see the list in the Annexes of this report).

The CAFNET team has also written **11 chapters** (see list provided in the annexes of regional reports) on coffee agricultural and environmental issues **in 3 books published in 2010-11**:

Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. eds B. Rapidel, F.A.J. DeClerck, J. Le Coq, J. Beer, pp. 91-118. Earthscan, London.

Integrating Ecology and Poverty Alleviation and International Development Efforts: a practical guide. Ingram, J.C., F.A.J. DeClerck, and C. Rumbaitis del Rio (eds). Springer. New York.

Issues in Agroecology: Present Status and Future Prospects. Campbell B. & Lopez S (eds). Springer, London.

Dissemination material:

On top of this abundant scientific publication record, CAFNET has produced many documents (>100) targeted towards more applied goals for the local stakeholders as outlined above. They include:

- Proceedings of workshops with local stakeholders and authorities
- Reports and presentations of studies on specific topics such as value chains, eco-certification, organic coffee, carbon credits and payment for environmental services.
- Manuals with guidelines to monitor environmental services, to improve coffee practices and to promote tree diversity in coffee systems
- Manuals with guidelines to assess and analyse local knowledge.
- Articles published in local newspapers following interviews of the CAFNET teams in the 3 sub-continents.
- Books on trees and plants in coffee systems and landscapes.

As mentioned earlier, a detailed list is presented in the Annexes of the regional reports and 3 CDs (one per region) containing the main documents are provided with the present report.

2.5. Please list all contracts (works, supplies, services) above 5000€ awarded for the implementation of the action since the last interim report if any or during the reporting period, giving for each contract the amount, the award procedure followed and the name of the contractor.

In Uganda, a contract was signed in 2008 between the regional leader, ICRAF, and NUCAFE (The National Union of Coffee Agribusinesses and Farm Enterprises, Kampala – Uganda, represented by Joseph Nkandu, Executive Director) for 3 years and a total value of 41038 Euros in three instalments transferred after periodic assessments of the activities. This has allowed NUCAFE to organize consultations of the Ugandan coffee stakeholders, train farmers on good agroforestry practices, sensitize farmers on biodiversity and environmental issues, collect information on coffee value chain, and implement their "Farmer Ownership Model" with 10 cooperatives certified with UTZ Certified.

2.6. Describe if the Action will continue after the support from the European Community has ended. Are there any follow up activities envisaged? What will ensure the sustainability of the Action?

- In Central America, CATIE, CIRAD and PROMECAFE (network of coffee institutes of Central America) has developed a long-term scientific platform during the course of the CAFNET project, specifically dedicated to the study of agroforestry systems with perennial crops (mainly coffee and cocoa). Therefore, this platform will continue to play a leading role in the region, particularly through its involvement in national initiatives on PES and eco-labels in relationships with NGOs, traders, certification agencies and local authorities.
  CAFNET has led to the development of scientific collaboration with the United States Fish and Wildlife Service on the movement of the borer and mammals in coffee dominated landscapes. A project on the adaptation of coffee systems to climatic changes in Central America has been accepted (FONTAGRO, a regional fund of the Inter-American Development Bank dedicated to agricultural technology) and will be starting late 2011; documentation work on the role of agroforestry practices at the farm and landscape levels in terms of adaptation to environmental changes will be a central issue of this project with

strong connections established during the CAFNET project with local stakeholders (farmers' cooperatives and eco-certification NGOs) and governmental institutions.

- In East Africa, ICRAF in collaboration with British research institutions (British Trust for Ornithology and University of Reading) and local research institutes and universities has submitted in early 2011 a project "Managing ecosystem services to reduce poverty and vulnerability in East African coffee landscapes" to the British cooperation fund (DFID/NERC). If accepted, this project will contribute greatly to follow up research and development activities undertaken by CAFNET. A second project "Enhancing food security and well-being of rural African households through improved synergy between Agro-Forestry" has also been submitted in April 2011 to the African Component of the ACP Research Programme for Sustainable Development (10th European Development Fund. Systems and Food-crops - EuropeAid/130-741/D/ACT/ACP). This pan-African project coordinated by CIRAD will be focusing its activities in Kenya for the East African region with collaboration of ICRAF and local universities and research institutions. In Uganda, NUCAFE will continue working with farmers' organizations on improving their governance and access to markets via links established during the course of the CAFNET project with the coffee sector and promoters of eco-friendly coffee. In Kenya, a project on geographic indicators (likely to start late 2011 and financed by the Agence Française de Developpement) will take advantages of the results and partnerships established via CAFNET. The international project "Coffee Initiative" funded by the Bill & Melinda Gates Foundation and implemented by TechnoServe in the East African coffee producing countries is also taking advantage of the results and experience of CAFNET.

- In India, the Coffee Board of India, one of the main partners of CAFNET with more than 50 years of existence and long-term support from the Indian government, is specifically dedicated to coffee research and extension towards coffee communities. This institution and UAS Bangalore will continue doing research on these environmental and agroforestry issues (via links established during CAFNET with the Department of Geography, University of Cambridge, UK) and disseminating the results and experience of CAFNET in the state of Karnataka (a series of workshops on bird friendly and organic coffee is already planned for the coming months with Smithsonian Migratory Bird Center, USA and Aditi Organics, Bangalore) and in other coffee producing states of India. CBI will soon be taking up two separate studies at the federal level (4 coffee producing states of Southern India) on "Prospectives for certified coffees production in India" and "Carbon Mapping across coffee chain" building on the experience acquired during the CAFNET project. The collaboration with the 2 international coffee traders (ECOM-Gill & NED Commodities) initiated by CAFNET will continue with CBI playing a leading role in helping individual farmers or farmers' groups to become certified as the managing institution of the financial scheme put in place in late 2010 by the Federal Government of India subsidizing up to 75% of the eco-certification cost.

2.7. Has the Action promoted gender equality, disabilities….? If yes, please explain[2]

CAFNET did not particularly focus its actions towards the promotion of gender equality and disabilities. Worldwide, coffee cultivation and marketing are still essentially a "Men's world". Nonetheless, the CAFNET team has been careful to involve as much as possible women, particularly during collection of traditional knowledge and participatory development of "best practices". In the 3 regions, CAFNET has made efforts to recruit females either as technical staff (including field technicians) or graduate students particularly originating from the target countries.

[2] To refer to EC Guidelines on gender equality, disabilities…

2.8. How and by whom have the activities been monitored/evaluated? Please summarise the results of the feedback received, including from the beneficiaries.

Only one formal external monitoring mission took place early in the project (September 2008) by Asia Monitoring Team ECORYS and solely in India. This monitoring mission was very useful to the CAFNET team especially for the “development and dissemination activities of CAFNET” during informal discussions with the ECORYS evaluator. However, we never received any official feedback from the EU with respect to this ECORYS monitoring mission. During this mission and a subsequent visit to EU headquarters in Brussels, we express your willingness to have such external monitoring also undertaken in the 2 other regions (East Africa and Central America), but no other monitoring mission of CAFNET has taken place during the following 3 years of the project.

In the 3 regions, steering committees have played an important role in informally monitoring and periodically evaluating the progress of CAFNET activities. As mentioned earlier, these committees constituted of a broad range of local stakeholders have contributed greatly in the definition of activity priorities at the onset of the project and in giving to CAFNET teams their feedbacks following periodic presentations of field work results and drafts of recommendations.
Feedbacks from individual farmers and farmers’ organisations have been tremendously positive during the course of the project and particularly during the final workshops. Many have expressed publically in these meetings their gratitude towards the participatory approach taken by the CAFNET team and the amount of technical information received (the exchange of information and experience on market strategies of farmers’ organizations within a region and across continents was particularly appreciated). Many organizations (including governmental authorities) have expressed their surprise that their collaboration with CAFNET went beyond the “traditional one on improving agricultural practices” and hence was also very rewarding in terms of 1) improving their organization governance, 2) accessing new eco-niche markets, 3) providing arguments and sound scientific bases for refining eco-certification criteria or better adapting forest laws to changing contexts, and 4) delivering constructive recommendations for developing pilot schemes for PES.

2.9. What has your organisation/partner learned from the Action and how has this learning been utilised and disseminated?

The project has comforted all the partners with the fact that a multi-disciplinary approach (i.e. collaboration of agronomists, coffee specialists, socio-economists, ecologists, extension experts, value chain and market specialists, etc..) with the participation of multi-stakeholders (i.e. farmers, NGO, local authorities, buyers, exporters) was the right one to tackle the complex goal of improving the wellbeing of coffee communities while preserving environmental resources. Not so surprisingly, partners have come to realize that rural communities had a tremendous amount and in-depth knowledge regarding environmental issues and effects of trees and agricultural practices on natural resources. This has greatly help to conciliate local knowledge with scientific documentation undertaken during the course of the project and to facilitate the constructive dialogue with farmers during the participatory development and testing of “best practices”. This close working relationship of the CAFNET teams with farmers and their organizations has also “legitimated” on the 3 continents the role of the CAFNET team in developing recommendations to NGOs and coffee traders promoting eco-friendly coffee and to local governmental authorities.

3. Partners and other Co-operation

3.1. How do you assess the relationship between the formal partners of this Action (i.e. those partners which have signed a partnership statement)? Please specify for each partner organisation

- CATIE played a highly valuable role as regional leader in Central America, particularly in consolidating the partnerships with local organizations in the 3 target countries, through its involvement in national initiatives on PES, frequent contacts with NGOs, traders and promoters of eco-labels, certification agencies and local authorities, and via its documentation work on environmental assessment and participatory development of sustainable coffee AF practices.
- ICRAF also played fully its role as regional leader in East Africa, towards coffee communities in the 3 pilot zones and at the national level in the 3 countries. In particular, a large effort has been dedicated towards analysing and disseminating information on value chains and certification schemes during the course of the project in view of the very high demand from farmers, cooperatives, local authorities and stakeholders of these marketing issues. During the last 2 years, ICRAF has strongly mobilized its experts and the ones of local research institutions to document more in-depth environmental services (especially carbon sequestration and biodiversity). Development activities to revive or develop nurseries and enhance availability of native tree seedlings for farmers of the target zones have been extremely appreciated by farmers and their organizations.
- The University of Agricultural Sciences Bangalore (UASB), the Coffee Board of India (CBI) and the French Institute of Pondicherry (FIP) have worked very efficiently towards the main goals of the project with solid relationships with all stakeholders on the ground. These institutions have worked particularly hard to document the environmental services provided by the highly diverse coffee agroforestry systems of this major coffee producing region of India and to sensitize local communities and authorities on these issues. They have also made a lot of efforts to provide information to farmers on certification schemes and in advising and training farmers' groups willing to become certified.
- University of Wales, Bangor (UWB) has played a leading role in advising the other institutions in the collection of data on uses and functions of trees and on traditional ecological knowledge, in analysing data and developing databases via AKT tools. This institution has also been key to insure that these results were incorporated into recommendations for sustainable coffee AF practices and selection of native species in order to maintain a balance between provision of environmental services and need of farmers' communities in terms of fuel wood, timber, fruits, fibres and other non-timber products.

Although costly and time-consuming, the international CAFNET workshops held in Costa Rica (September 2007), India (October 2008) and Kenya (August 2009) have greatly facilitated the exchange of experiences and results among all partners and across continents.

3.2. Is the partnership to continue? If so, how? If not, why?

As pointed out previously, the partnership between CIRAD and partners in Central America and East Africa will be continuing through existing platforms with the development and implementation of joint projects. In India, partnership will continue among Indian institutions in the form of jointly organized workshops to disseminate CAFNET results and experience on eco-certification and "best practices", but less formally with European institutions (CIRAD and UW Bangor) in the absence of a new international project.
All the partners on the 3 continents have expressed their willingness to maintain contact and exchange of information across continents and the idea of developing a coffee agroforestry information network (keeping the acronym of CAFNET) is "in the air".

3.3. How would you assess the relationship between your organisation and State authorities in the Action countries? How has this relationship affected the Action?

Before the start of the CAFNET project, CIRAD was already well known by State authorities in Central America and East Africa through its long term collaboration in these regions with the two regional leaders of CAFNET, namely CATIE and ICRAF, as well as national coffee research and extension institutions. Therefore, the CAFNET project has been viewed very favourably by these authorities with no problem in its day to day implementation.
Through its CAFNET collaboration with 3 well-known institutions (UASB, CBI & FIP), CIRAD has now established solid contacts in India with local representatives of authorities and stakeholders of the coffee value chain.

3.4. Where applicable, describe your relationship with any other organisations involved in implementing the Action:

- Associate(s) (if any)

Local coffee cooperatives and rural development organizations (COOMPROCOM and CAFENICA in Nicaragua; APOT in Costa Rica; ADIPSA in Guatemala; NUCAFE in Uganda; COOPAC in Rwanda, MUGAMA Cooperative Union in Kenya; Kodagu Planters Association and Kodagu Coffee Growers Cooperative Society in India) have fully interacted with CAFNET teams over the entire course of the project.

Coffee research institutions or NGOs involved in promoting eco-labels (such as ANACAFE and the NGO “Defensores de la Naturaleza” in Guatemala, COREF and NUCAFE in Uganda, CRF in Kenya, ICAFE in Costa Rica, Coorg Wild Life Society in India) have also fully cooperated with the CAFNET teams in the field and during workshops with farmers.

As pointed out in previous reports, expectations in terms of capacity building and connection to the eco-markets have been very high from cooperatives and/or coffee communities of the two regions (East Africa & India) that were fairly new to this concept of eco-marketing in comparison to the ones of Central America that have learnt from experience of the difficulties in securing long-term access to eco-markets with good premium for their members.

- Sub-contractor(s) (if any)

Due to its dynamism and connection to coffee farmers’ communities in the field, NUCAFE was a sub-contractor of CAFNET in Uganda for almost the entire duration of the project (3.5 years) and worked very efficiently particularly on capacity building of cooperatives and dissemination of information on access to eco-markets.

- Final Beneficiaries and Target groups

Target groups (members of cooperatives) and final beneficiaries (rural communities and other stakeholders of the coffee sector) showed great interest in the project via their participation in activities (traditional ecological knowledge, biodiversity inventories, environmental impact assessment, economic surveys of farms, studies of value chain) and large attendance to dissemination meetings and steering committees.

- Other third parties involved.

In the 3 regions, NGOs (particularly Rainforest Alliance and UTZ Certified) and the private sector (Starbucks and Nespresso) including international traders (ECOM, GILL, Ned-Commodities) and large coffee estates (Tata Coffee, BBTC) were very much involved in the project through participation in steering committees and testing changes in their agricultural management criteria to make them more locally adapted and environmentally relevant.

This involvement of a broad range of stakeholders of the coffee chains was certainly important for the success of the CAFNET project, but more importantly for the sustainability of this initiative promoting and rewarding eco-friendly coffee agroforestry practices as this has reinforced relationships between farmers and these promoters of eco-markets.

3.5. Where applicable, outline any links you have developed with other actions

Many links were established during the course of CAFNET with other actions/projects dealing with coffee and environmental issues, and/or coffee marketing and the improvement of the wellbeing of coffee communities. The main important ones are:

- In East Africa, the Pro-Poor Rewards for Environmental Services in Africa (PRESA) project implemented by ICRAF.
- In Rwanda with ACDI VOCA financed by USAID.
- In Nicaragua, the Learning Alliance for Rural Business Development counting as members CIAT, CRS, GTZ, Rainforest Alliance, CARE, Oxfam and CATIE.
- In India, the Biodivalloc project financed by the French Research Agency studying the feasibility of Geographic Indications as a way to add value to products derived from a specific “terroir” with high environmental values.
- In India with National Center for Biological Sciences, Bangalore, carrying out research on biology, and environmental sciences in agricultural landscapes.
- In East Africa, the project “Coffee Initiative” funded by the Bill & Melinda Gates Foundation and implemented by TechnoServe.
- In Costa Rica, the national initiative to put in place a payment for environmental services for the coffee sector in collaboration with the Ministries of Agriculture and Environment and COOCAFE and Fundación Café Forestal and ICAFE.

3.6. If your organisation has received previous EC grants in view of strengthening the same target group, in how far has this Action been able to build upon/complement the previous one(s)? (List all previous relevant EC grants).

As pointed out in previous reports, CIRAD coordinated the CASCA project (Coffee Agroforestry Systems of Central America) funded by EU (Inco-Dev: ICA4-2001-10071) from 2001 to 2005 that took place in Costa Rica, Nicaragua and Guatemala, the 3 Central American countries where CAFNET was implemented thereafter. CASCA was implemented in collaboration with CATIE, the main partner of the CAFNET project in the region, and focused mostly on scientific issues. Clearly, this CASCA project has facilitated the partnership with the regional leader and many local stakeholders in Central America as exposed previously.

3.7. How do you evaluate co-operation with the services of the Contracting Authority?

Cooperation has been very constructive in terms of administrative and financial matters with 2 consecutive officers in charge of managing CAFNET. It is our understanding the second officer in charge has recently taken a new position at the EU headquarters and it would have been useful if an EU notification had been sent to us mentioning the new officer in charge of CAFNET.

4. Visibility

How is the visibility of the EU contribution being ensured in the Action?

This was done very classically by 1) systematically acknowledging EU for its financial contribution in any presentation (local ones with farmers, and national or international ones in seminars or congresses) or scientific publication done by any partner of the project and 2) putting EU logo on cars bought by the project, on banners during workshops and on notepads or pamphlets distributed to farmers during dissemination meetings.

The European Commission may wish to publicise the results of Actions. Do you have any objection to this report being published on EuropeAid Co-operation Office website? If so, please state your objections here.

No objection at all.

Name of the contact person for the Action: Philippe Vaast

Signature:

Location: Montpellier, France

Date report sent: 30/09/2011

CAFNET Final Report (January 2007 to September 2011)

FINAL REPORT - INDIA REGIONAL CENTER

Coffee Agro-Forestry Network (CAFNET) – Connecting, Enhancing and Sustaining Environmental Services and Market Values of Coffee Agro-Forestry in Central America, East Africa and India

Program on Environment in Developing Countries
Financed by European Commission

College of Forestry, Ponnampet
University of Agricultural Sciences, Bangalore, India
2011

CAFNET INDIA

Final Report

(January 2007 to September 2011)

Table of Contents

Introduction

Background

India is an important coffee growing region in the world with a contribution of about 4% towards global coffee trade. India produces both Arabica and Robusta coffee in an area of about 400,000ha with an average annual production of 300,000MT (Coffee Board of India 2011). About 70% of country's production is exported and the rest is consumed in domestic market. Coffee if mainly grown in the three Southern states of Karnataka, Kerala and Tamil Nadu Coffee in the forested hills falling under the western Ghats , which is recognized as one among the eight hottest hot spots of biodiversity in the world by the IUCN. These diverse ecosystems of Western Ghats have contributed to evolution and sustenance of a range of biodiversity which includes 8% of India's flora, the largest population of Asian elephants and tigers, 350 species of birds and a variety of rich other biota with a very high proportion of endemic taxa. All the coffee grown in India is shade grown at high elevations. In addition coffee sector provides employment opportunities for nearly a million people in the areas like production, processing and value addition.

Kodagu district is the largest coffee growing region in India producing about 38% of India's coffee and is also known as the land of river Kavery, which is a lifeline for several million farmers in the states of Karnataka and Tamil Nadu as well as source of drinking water to many urban town and cities including Bangalore. The river Kavery is worshipped by the local people as Goddess Kavery. Realizing the significance of river Kavery, the pioneering farmers of Kodagu have adopted a shade grown agro-forestry system for cultivation of coffee, cardamom and other plantation crops as well as paddy cultivation in low lying areas amidst coffee areas. Over a period of time, coffee intercropped with black pepper and orange has established as major cropping pattern in the district. Today, the coffee plantations of Kodagu are recognized as one of the most diverse coffee production systems in the World. The shade grown coffee plantations cover 33% of the landscape of the district complimenting the other forested landscapes like reserve forests and protected areas, sacred forests and other wooded areas. With these diverse forested ecosystems which cover 78% of the total land area of the district, Kodagu has been identified as a micro hotspot of biodiversity within the larger Western Ghat region. The district with one national park and three wildlife sanctuaries under the formal government managed system of protection, a network of 1214 sacred forests under the informal community managed areas and about 104,000ha of coffee plantations provide an unique opportunity for the researchers to study the key issues of sustainable landscape management. In addition to hosting the diverse and unique biodiversity the forested ecosystems provide a range of ecosystem services which sustains the livelihood of the local communities.

Coffee is one of the key drivers in the development of Kodagu district. The cultivation of coffee was promoted by British during 1860 and coffee planters developed a unique system of cultivation under the shade of natural tree cover without impacting the environment in an eco friendly manner. The long period of drought from November to April ensured retention of canopy cover for protection of plants and flowers which occurred during the month of Feburary –March. As of today, coffee in the district is cultivated by about 42,000 farming families, covering a total area of 104,000 ha. (75,500ha of Robusta and 28,500 ha of Arabica) with a production of about 110,000 MT.

The multistoried coffee agro forestry system developed and sustained by the farmers based on their local knowledge is one of the most diverse production systems in the world. In addition to contributing to employment and economic development of the region, the coffee plantations under multistoried agro forestry system sustain biodiversity in the form of flora and fauna and in term contribute to valuable ecosystem services in terms of hydrological services and carbon sequestration. Earlier studies by (Ambinakudige & Satish 2009; Bhagwat 2002; Elouard & Guilmoto 2000) on Coffee Based Agro forestry systems in Kodagu have indicated the richness and uniqueness of the biodiversity present in the coffee plantations in comparison to other forested landscapes in the district. In addition to hosting a rich biodiversity, the diversity of crops in the system like coffee, black pepper, Kodagu mandarin, cardamom vanilla and valuable timber trees provide additional resources to farmers and help them to overcome the economic crisis during the coffee crisis period. Hence, the coffee production system of the Western Ghats including Kodagu has been identified as one of the most diverse and resilient coffee production system in the world.

This unique and diverse multistoried agro forestry system is undergoing transformations with respect to canopy densities and diversity due to changes in the production systems due to the current liberalized market situation. There is a gradual increase in area under coffee cultivation either by converting privately owned wooded areas or by converting existing cardamom plantations. An assessment of change in forest cover during the 20 years between 1977 and 1997 indicated that the forest cover has declined by 28% from 2566 km^2 to 1841 km^2 representing a reduction of 18% the forest cover in the total area. The most depleted forest type is medium elevation evergreen forest which decreased by 35% (representing 9% of the total area). Low elevation ever green forests have shrunken by 17 % (1% of the total area). Moist deciduous forests decreased by 7 % (2% of the total area). A large part of it had been converted into coffee and teak plantations after 1977. Most of the areas converted into coffee plantations are privately owned areas (Moppert 2000). In addition to conversion of wooded areas and other cropped areas into coffee areas, there is another important change in the characteristic of coffee holdings. Most of the estates previously planted with Arabica coffee and maintained under a good cover of mixed shade are being converted to Robusta coffee which requires sparse shade resulting in decrease in canopy cover and population of native tree species in the coffee area. The Robusta coffee plantations which had higher density and diversity of shade earlier are now becoming more open and the diversity is also coming down since planters are replacing native trees with exotic Silver Oak *(Grevillea robusta)* to increase productivity of their coffee holdings and to overcome difficulties related to shade management and marketing of native trees.

This intensification of coffee production through shade reduction and replacing native trees with exotic trees in the ecologically fragile areas where coffee is being cultivated, may lead to long term effects on the environment which might affect the ecosystem services like water supply, carbon storage and bio-diversity. Thus it is imperative to promote sustainable management of coffee agro-forests which involves protection of environment and economic viability of coffee producers.

The Indian component of CAFNET project

The project “Coffee Agro-Forestry Network (CAFNET) – connecting, enhancing and sustaining environmental services and market values of coffee agro-forestry in Central America, East Africa and India” funded by the European Union and executed by CIRAD, France was implemented in Kodagu (Kodagu) district of Karnataka, India by three local partners viz., University of Agricultural Sciences, Bangalore (UASB); Central Coffee Research Institute, Coffee Board of India (CBI) and French Institute of Pondichery (FIP) from June 2007 to May 2011.

College of Forestry of the University of Agricultural Sciences (Bangalore) located in Ponnampet in the district of Kodagu was the Indian regional centre and provided the logistic support for the project team. Additionally researchers from other institutions both from within and outside the country participated in specific aspects of the study and details of the team members is provided in ANNEXURE 1.

This report pertains to the salient achievements/ findings under different activities implemented by the UASB and CBI during the full period (January 2007 - June 2011) of operation of CAFNET project in India.

Activity 1.1. Identification of watersheds and target communities.

For the identification of watersheds and target communities a multidisciplinary approach was followed involving consultations with local stake holders of the coffee industries, government agencies and understanding the landscape from a spatial perspective using geo-informatics tools. Project team undertook field visits in Kodagu district and held discussions with officers of line departments like watershed, forest, revenue and agriculture.

Identification of watershed for further studies

The data was presented in a Geographical Information System (GIS) platform to local stakeholders, government officials and scientific in a meeting held at the office of the Kodagu Wildlife Society to select the watershed and target communities on March 2nd 2007. The GIS presented was developed using administrative data, satellite imagery from the IRS P6 satellite, previous vegetation maps developed by the French Institute of Pondicherry and freely available SRTM digital elevation data. To understand the dynamics in coffee expansion in the district the land use map of Kodagu district at the scale of 1:2 500 000 was updated using 23 meter resolution satellite imagery. The land use/vegetation type classification was based on the vegetation type classification of Pascal JP and Ramesh BR published by the French Institute of Pondicherry (Fig. 1A, B and C).

The classes include the following:

1. Cultivated and settled area
2. Low elevation evergreen forests
3. medium elevation evergreen forests
4. high elevations evergreen forests
5. Secondary Moist deciduous forests
6. Moist deciduous forests
7. Dry deciduous forests
8. Coffee
9. Tea
10. Teak and eucalyptus plantations
11. Rivers and reservoirs

Using the previously available land use maps and the updated map for 2007 the change in land use was mapped with special emphasis on emphasis on coffee expansion (Fig. 2). The expansion in coffee cultivated area is evident in the last 30 years throughout the district. In the last 10 years the expansion in coffee cultivation essentially happens in the central western and north western parts of the district.

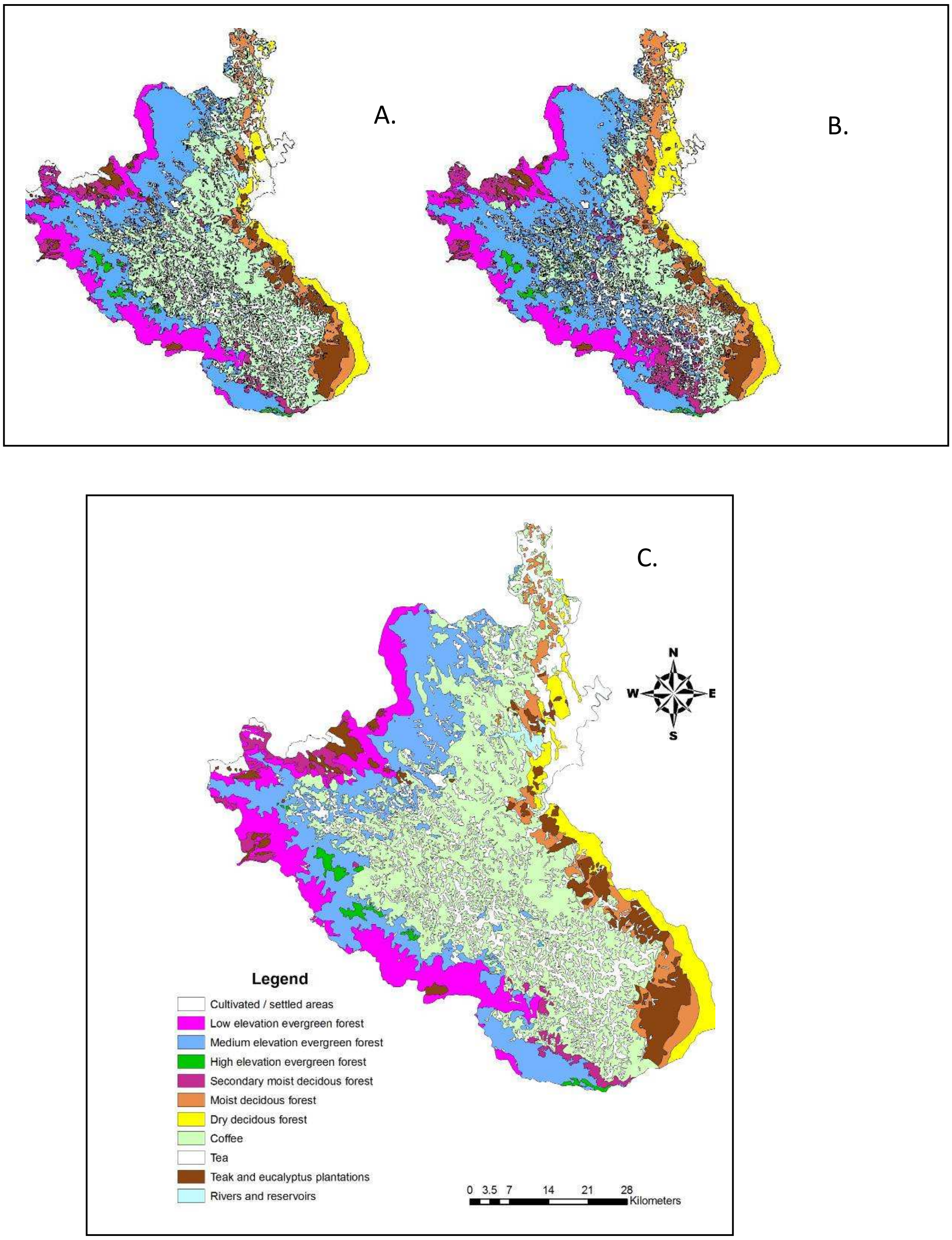


Figure 1: Land use map of Kodagu district (1:2 500 000). Map prepared with 23 meter resolution satellite imagery. The land use/vegetation type classification is based on (Pascal 1982). The maps show the changes in land-use between 1977 (a), 1997 (b) and 2007 (c).

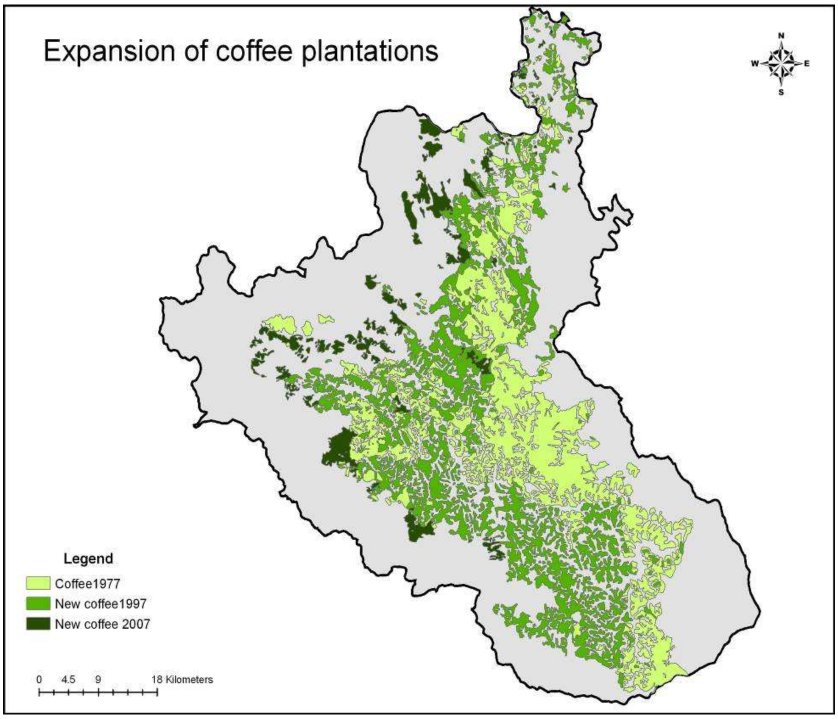


Figure 2: Land use map of Kodagu district (1:2 500 000). Map prepared with 23 meter resolution satellite imagery. The land use/vegetation type classification is based on (Pascal 1982).

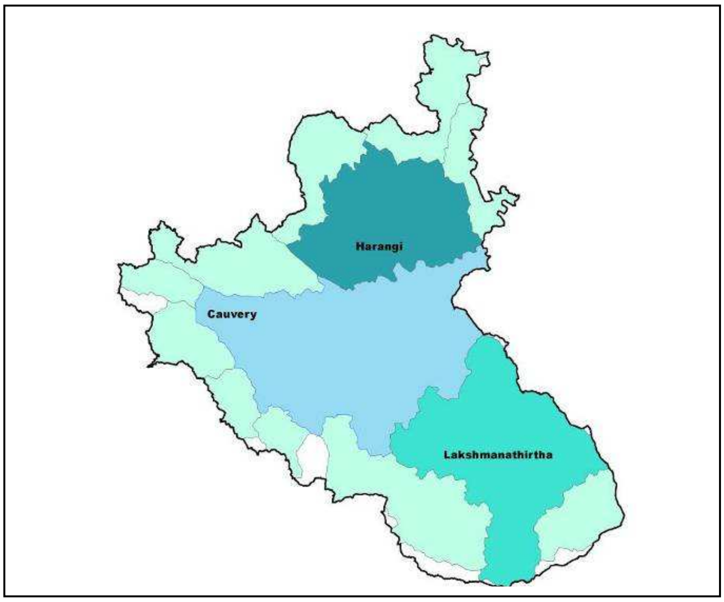


Figure 3: Watersheds of Kodagu extracted from SRTM data. Of the three major watersheds, the steering committee recommended CAFNET to focus on the Kavery (Kavery) watershed for its size, population density, production systems and also its symbolic significance, Kavery being a sacred river for the traditional communities of the district.

We used Shutter Radar Topological Mission (SRTM) to delineate the watersheds of the district (Fig. 3). The data on expansion of coffee and the various watersheds within Kodagu were presented to the stakeholders for deliberations and after discussion the Kavery watershed was selected as a study area for the CAFNET project from among the three watersheds in the district.

Selection of study villages:

For the identification of the study villages for the various inventories, we randomly selected 35 villages from the Kavery watershed (Fig. 4). Baseline information and maps for all these selected villages were collected from various government and private sources. The land use based obtained from the 2007 maps created on purpose by the FIP (Fig.5). Details of all the farmers and their land holdings were gathered from the revenue department. In each of the selected villages one large, one medium and one small farmer were randomly selected for biodiversity data collection, soil data collection and economic data collection. The list of respondents is provided in Annex 2. These differ from the respondents for the study on local knowledge, who were selected through snowball sampling from the entire watershed.

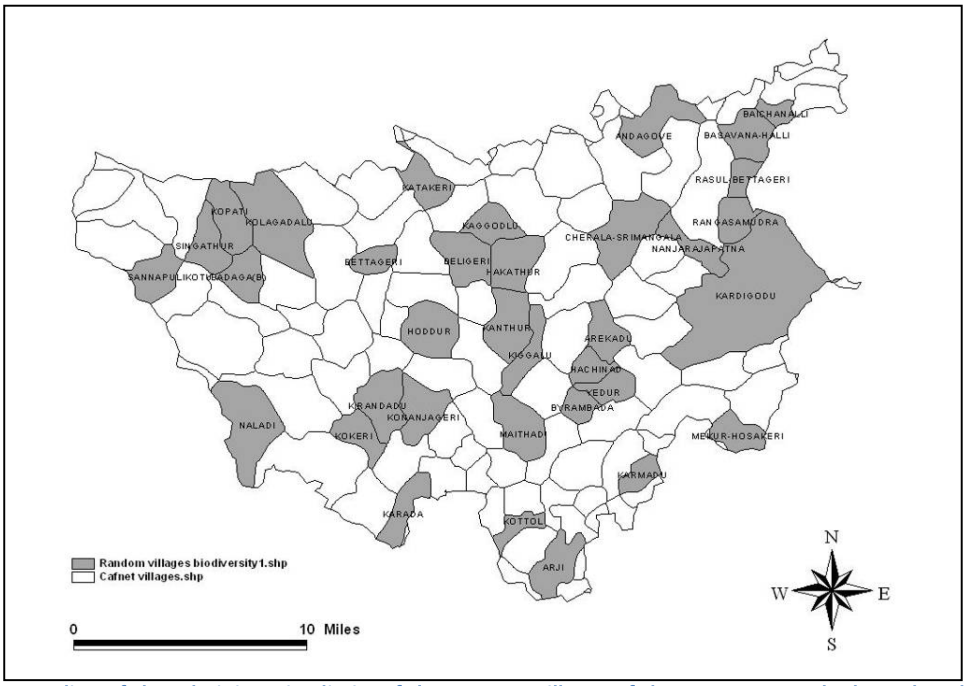


Figure 4: Outline of the administrative limits of the revenue villages of the Kavery watershed, used to design the stratified sampling. In grey the 35 villages selected for biodiversity and economic assessment and soil collection.

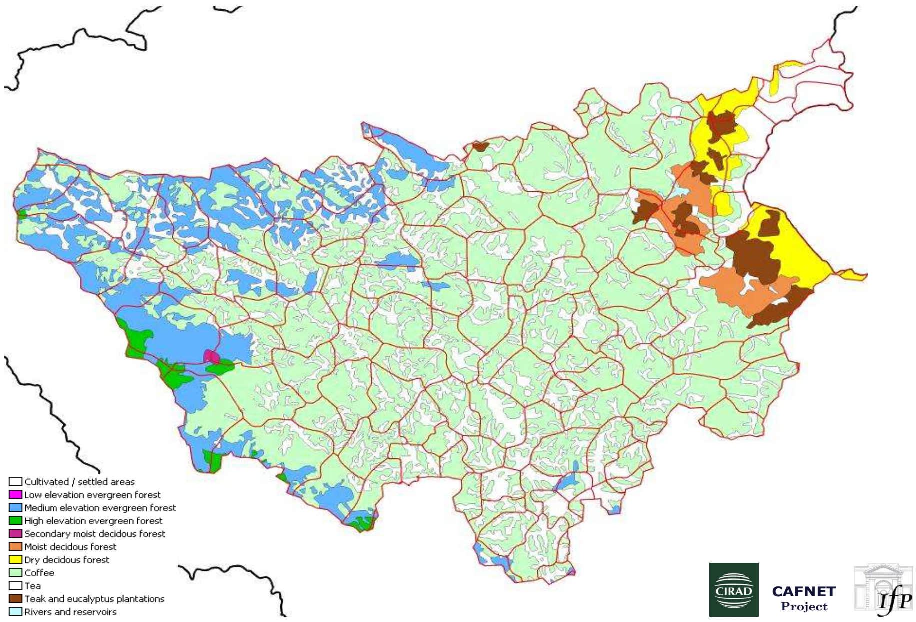


Figure 5: The map shows the limits of the revenue villages of the Kavery watershed over the land-use of the 2007 map.

Activity 1.2. Multi-sector steering committee meetings

Figure 6: Meeting of the steering Committee, Coffee Board Research Station, Chettalv (17/09/2009).

A multi-sector Steering Committee comprising of representatives of different sections of coffee sector viz., producers, traders of coffee & other products, NGO's, researchers and extensionists, local government and public organizations was constituted on 2nd March 2007. The composition of Steering Committee is given in Annexure 3. This Steering Committee actively participated in formulation of plans for implementation of the project activities, monitoring of outcomes and adjustment of activities in a cycle of adaptive management in association with the project team. During the entire duration of the project, the Steering Committee met on

12 occasions and guided the project team in implementation of project activities from time to time. The details of the meeting held is provided in Annexure 4

Activity 2.1: Traditional agroforestry knowledge.

A detailed documentation of local knowledge of farmers about various interactions in multi-strata coffee agro-forests was carried out to assess its relevance in the development and implementation of sustainable coffee agro-forestry practices. This is the first effort of its kind in India where the elicited local knowledge was built into digital knowledge bases using Agroecological Knowledge Toolkit (AKT) software. This helps in easy and quick access of information in searchable modules.

Training on Agroecological Knowledge Tools (AKT)

Training and support in the acquisition of local agro ecological knowledge using tested knowledge based systems/methods were imparted to the team India by the University of Wales, Bangor. The program was conducted by Dr. Fergus Sinclair, School of Agricultural and Forest Sciences, University of Wales, Bangor**,** and was organized at College of Forestry, Ponnampet. The training was held from 30th April 2007 to 12th May 2007 and was attended by 21 members including post graduates, teaching staff, team from French Institute of Pondicherry and Coffee Board of India.

npet College of Forestry, May 2007.

ge

AKT field work

Based on the discussions held with the project team and members of stakeholders committee, it was decided to collect information on Traditional Ecological Knowledge (TEK) for two vegetation types namely the evergreen and the moist deciduous. The villages were selected randomly in Kavery watershed area. The list of study sites for acquisition of local traditional ecological knowledge in coffee agro forestry are as provided in Annexure 5.

The knowledge of stakeholders (planters, supervisors and workers) was gathered in a stratified manner on four different topics viz., floral diversity, faunal diversity, tree interactions and byproducts with help of four teams constituted using non-leading questions to the local stakeholders. Each group elicited information from 20 respondents under each category for two target vegetation types. The stratification method followed for eliciting floral diversity component is given as an example in annexure 6. Totally, 49 villages and 240 stakeholders have been interviewed. The knowledge gathered was keyed into the AKT module in the form of unitary statements and object hierarchies.

Figure 9: Gathering local knowledge.

Currently we have a total of 6 knowledge bases. Fine tuning of all the knowledge bases is through with images uploaded on to the knowledge bases. A reference knowledge base has been developed to aid in further entry of terms into the knowledge bases. In addition to the four knowledge base developed by the team, another two knowledge bases i.e. on pruners' knowledge and the another on rainfall and weather predictions have been developed in collaboration with University of Wales, Bangor. Two students from the University of Bangor have done their project work under CAFNET India. Mr. Mahfuz has worked on "Local knowledge of tree pruners about biodiversity associated with coffee agroforestry systems in Kodagu district of India" and Mr.Raju Sharma studied "Local knowledge of the effects of climate change on water regimes within coffee agroforestry systems in the Western Ghats of India"

In order to test whether the knowledge bases developed represent the stakeholders' knowledge in the watershed, "Generalisation" procedure was followed and it appeared that the knowledge bases developed fairly represent the community knowledge to the tune of 70 % which is very significant. Scoring and Ranking analysis were also taken up to come out with the list of suitable trees encompassing all the components of biodiversity. The results have been presented at the second international CAFNET workshop held at Forestry College, Ponnampet.

The local knowledge elicited from the farmers has been built into the knowledge bases. These knowledge bases are hosted in http://www.ifpindia.org/Managing-Biodiversity-in-Mountain-Landscapes.html for public use; the AKT software can be downloaded from http://akt.bangor.ac.uk/ for accessing these knowledge bases.

The project team has brought out two publications (please see the list below), one on local knowledge of farmers and the other on Trees of coffee agroforestry systems. First publication gives the documented information from farmers on issues such as shade management, coffee management, biodiversity conservation, rainfall, irrigation, soil and moisture conservation, fertilizer application, pest and diseases and aspects of production, productivity and quality of coffee. There is vast information available with farmers crucial for biodiversity conservation and management. Another publication is a field guide giving information on common names, phenology, distribution, identification features, propagation and uses of 202 trees of the coffee agroforestry systems along with representative photographs.

Publications

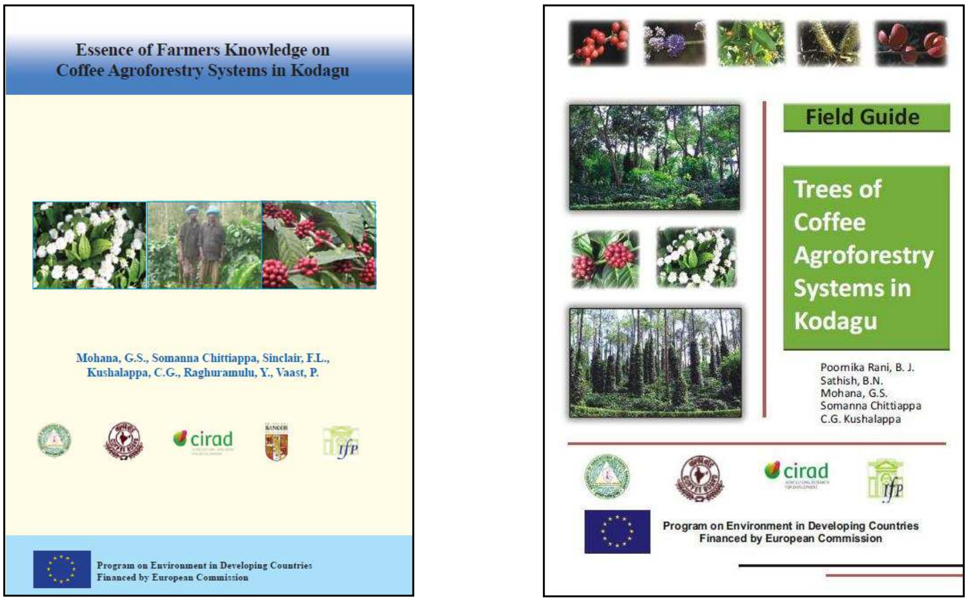


Figure 10: Book cover of the two productions of the CAFNET India Traditional Knowledge activities: "Essence of Farmers Knowledge on Coffee Agroforestry Systems in Kodagu" and "Trees of Coffee Agroforestry Systems in Kodagu".

Glimpse of the information on shade trees available in the publication 1

Tree species	Remarks
Trees with good quality shade	
Dadap/Haluvana (*Erythrina lithosperma*), Nerale mara(Syzygium cuminii), Balanji (Acrocarpus fraxinifolius) and Atti mara (Ficus glomerata)	sheds leaves during monsoon
Baage mara (Albizia lebbeck)	increases yield of coffee
Jackfruit (Artocarpus heterophyllus)	gives appropriate shade
Kulumavu (Persea macrantha)	Smooth leaf texture with cooling

Tree species	Remarks
	effect
Silver oak (*Grevilia robusta*)	tall growing, less branches with small leaves; desirable, especially for Robusta, when planted judiciously
Trees whose shade is NOT preferred	
Rose wood (*Dalbergia latifolia*)	High nutrient absorption; spreading habit of this tree is a concern
Nandi (*Lagerstroemia microcarpa*) and Teak (*Tectona grandis*)	sheds leaves during summer
Tamarind (*Tamarindus indica*)	allelopathic effect
Kokum (*Garcinia indica*)	high nutrient absorption

Impact of the work:

The AKT work has culminated in 6 informative knowledge bases and two publications as mentioned above. These outputs in fact represent the baseline data available on farmers' vast knowledge and trees of coffee agroforestry systems with the researchers which were so far not available. The stakeholders in the Kavery watershed area are well aware of these studies and there is a significant increase in the level of understanding of these issues among stakeholders which we hope, will help in sustainable management of the agroforestry systems. Further, it is pertinent to note that these outputs were well received during the final CAFNET workshop that aimed at dissemination of information to the various stakeholders.

Future lines of work:

1. Identification of researchable questions related to biodiversity conservation from the knowledge bases and working on them
2. Revising the publications with latest information on tree species, photos etc.
3. Hosting the information in field guide on trees on to an interactive web space
4. Maintain constant interaction with stakeholders of the study to assess the dynamics of information exchange and on ground action.

Activity 2.2 Biodiversity inventories in coffee agro forestry landscapes.

Tree Biodiversity

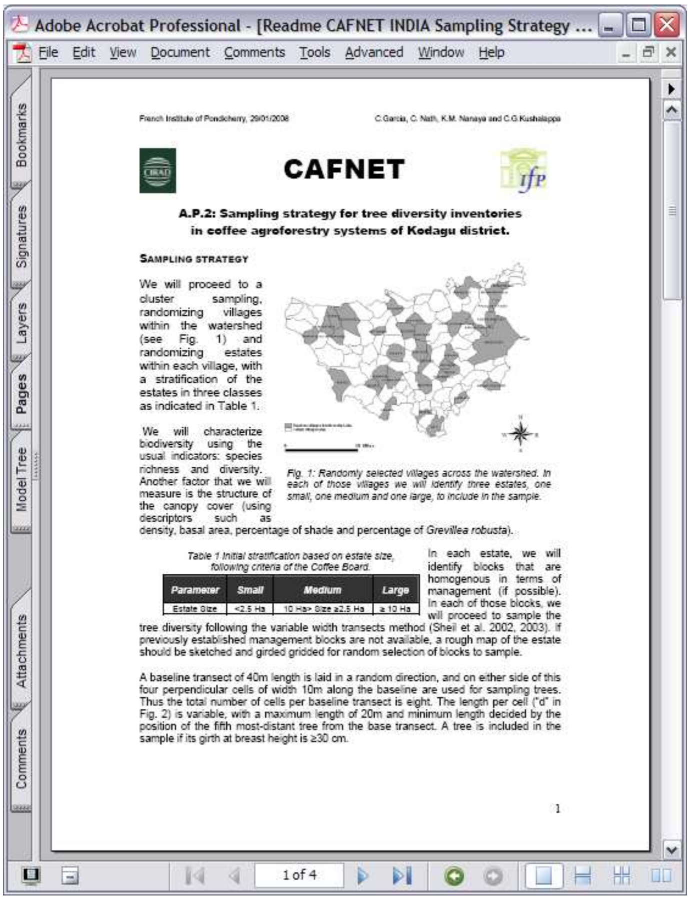
Protected areas are the foundations of conservation strategies of government and international institutions world over. Over the last 50 years, we have modified our environment at an unprecedented scale to provide for our needs. The demand for food, firewood, freshwater, timber and other natural products is putting stress on the ecosystems, undermining their capacity to deliver other services we depend upon. Cultivated systems now represent one quarter of the world's surface. And this in turn has led to widespread simplification of the ecosystems converted and a loss of ecological processes, species and genes. They key challenge, in an increasingly crowded world, is therefore to maintain the ecosystems, ensuring the delivery of these services that sustain our societies, outside protected areas, as further extension of these is unlikely. As Biodiversity underpins most of these services, the question is thus how to maintain biodiversity in production landscapes.

A crop such as coffee, whose area of production largely overlaps with many of the world's biodiversity hotspots, offers a good model to understand these links and propose principles of landscape management that will balance conservation, the need for development of the local communities, and the provision of a crop of global significance.

CAFNET India set therefore to document the existing biodiversity in the coffee agroforestry landscape of the Western Ghats, the major area of production in India, and more specifically in the Kavery watershed (Kodagu district). Earlier studies (Bhagwat 2002; Elouard & Guilmoto 2000; Muthappa et al. 2001) indicated the richness of flora and birds among the coffee plantations in Kodagu. Our results confirm the coffee agroforestry system of Kodagu is one of the most diverse shade grown coffee production systems in the world. However, as our results show, this system is currently undergoing a transition towards simplified, more intensive production systems. There was therefore an urgent need to document its biodiversity so as to better understand its links with the provision of critical ecosystem services and raise awareness in the local and global community of the conservation value of this production system.

We adopted an integrated approach to assess the different guilds (trees, epiphytes, microbial, birds and mammals) that contribute to the biodiversity of the system and to understand its links with other parameters in the production system. As such, most of our work used a common sampling approach.

Methods


Adobe Acrobat Professional - [Readme CAFNET INDIA Sampling Strategy ...

File Edit View Document Comments Tools Advanced Window Help

French Institute of Pondicherry, 29/01/2008 C.Garcia, C. Nath, K.M. Nanaya and C.G.Kushalappa

CAFNET

A.P.2: Sampling strategy for tree diversity inventories in coffee agroforestry systems of Kodagu district.

SAMPLING STRATEGY

We will proceed to a cluster sampling, randomizing villages within the watershed (see Fig. 1) and randomizing estates within each village, with a stratification of the estates in three classes as indicated in Table 1.

We will characterize biodiversity using the usual indicators: species richness and diversity. Another factor that we will measure is the structure of the canopy cover (using descriptors such as density, basal area, percentage of shade and percentage of *Grevillea robusta*).

Fig. 1: Randomly selected villages across the watershed. In each of those villages we will identify three estates, one small, one medium and one large, to include in the sample.

Table 1 Initial stratification based on estate size, following criteria of the Coffee Board.

Parameter	Small	Medium	Large
Estate Size	<2.5 Ha	10 Ha> Size ≥2.5 Ha	≥ 10 Ha

In each estate, we will identify blocks that are homogenous in terms of management (if possible). In each of those blocks, we will proceed to sample the tree diversity following the variable width transects method (Sheil et al. 2002, 2003). If previously established management blocks are not available, a rough map of the estate should be sketched and girded gridded for random selection of blocks to sample.

A baseline transect of 40m length is laid in a random direction, and on either side of this four perpendicular cells of width 10m along the baseline are used for sampling trees. Thus the total number of cells per baseline transect is eight. The length per cell ("d" in Fig. 2) is variable, with a maximum length of 20m and minimum length decided by the position of the fifth most-distant tree from the base transect. A tree is included in the sample if its girth at breast height is ≥30 cm.

1

1 of 4

Figure 11: Spreadsheet describing the Biodiversity sampling protocols.

Figure 12: CAFNET Team Biodiversity Sampling - 14/02/2008

We focused our sampling strategy on a stratified random approach. Thirty five revenue villages along the Kavery watershed area were randomly selected. Within these villages, farmers were randomly selected based on land record survey numbers collected from the respective revenue offices. The farmers were categorized into large, medium and small farmers based on the area of ownership and representing three different management regimes: within each village, we thus selected one large (size > 10 Ha), one small (size below 2.5 Ha) and one medium estate (2.5 Ha< size < 10 Ha). A total of 105 estates have thus been sampled, with information on tree cover density and structure, basal area, species composition and management regimes (a detailed description of the sampling strategy can be found in the file Readme CAFNET INDIA Sampling Strategy File.pdf) Within the same sample, micro-economical data on the production system was been recorded so as to link the production costs and profitability with the measures of biodiversity.

Pilot Study

Figure 13: Measuring tree girth in the coffee estates. 16/02/2008

Four different protocols that could be used to describe the tree cover of the coffee agroforestry systems in terms of species composition and structure were identified (see Readme CAFNET INDIA Sampling Protocol.pdf). Those four protocols where discussed in the September workshop and tried out through a pilot study in a set of situations: *Coffea canephora* estates, *Coffea arabica* estates and forest fragments. Based on the number of trees captured per hour of sampling, the most efficient protocol, based on the Multidisciplinary Landscape Assessment method developed by CIFOR was chosen. A detailed description of the pilot study has been published in Agroforestry Systems (Nath et al. 2009). The protocols have been disseminated to the CAFNET partners in Central America and East Africa through spreadsheets (Fig. 11). Biodiversity sampling started in January 2008 and was jointly conducted by all three partners (UAS, CB and FIP, Fig. 12). It involved approx 68 man/months of fieldwork, shared between the three partners (6 for the CB, 18 for the FIP and 44 for the UAS).

With the data collected on management regimes, we did a post stratification based on the typology of the production systems (Decroix & Chretien 2007). Pre stratification was not a viable option due to logistical constraints and the difficulty to identify the estate owners based on the survey maps available. The data sheets once filled were stored in the archives of the College of Forestry, with two sets of copes deposited one in another office of the CoF and a second at the FIP. Standard procedures of quality control were developed to ensure the final data set is as much error free as possible.

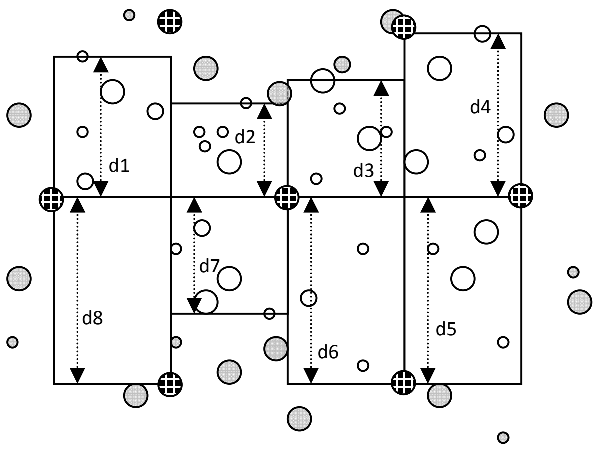
On field documentation involved the following steps:

- Post stratification questionnaire at estate level to identify relevant criteria for various stratifications (see file CAFNET Datasheet Estate.doc)
- Depending on the farm size and types of vegetation, 4 to 6 transects were randomly selected within each farm for the inventory. A cutt-off line of 200 trees per estate was decided based upon the results of the pilot study.

- For each transect, recording of GPS coordinates & topographic observations, tree data comprising data on species, GBH, volume and Densiometer readings and soil samples for biophysical characterization (Fig. 13).

Box 1: Tree Biodiversity Protocol (from Reame CAFNET INDIA Sampling Protocol.pdf).

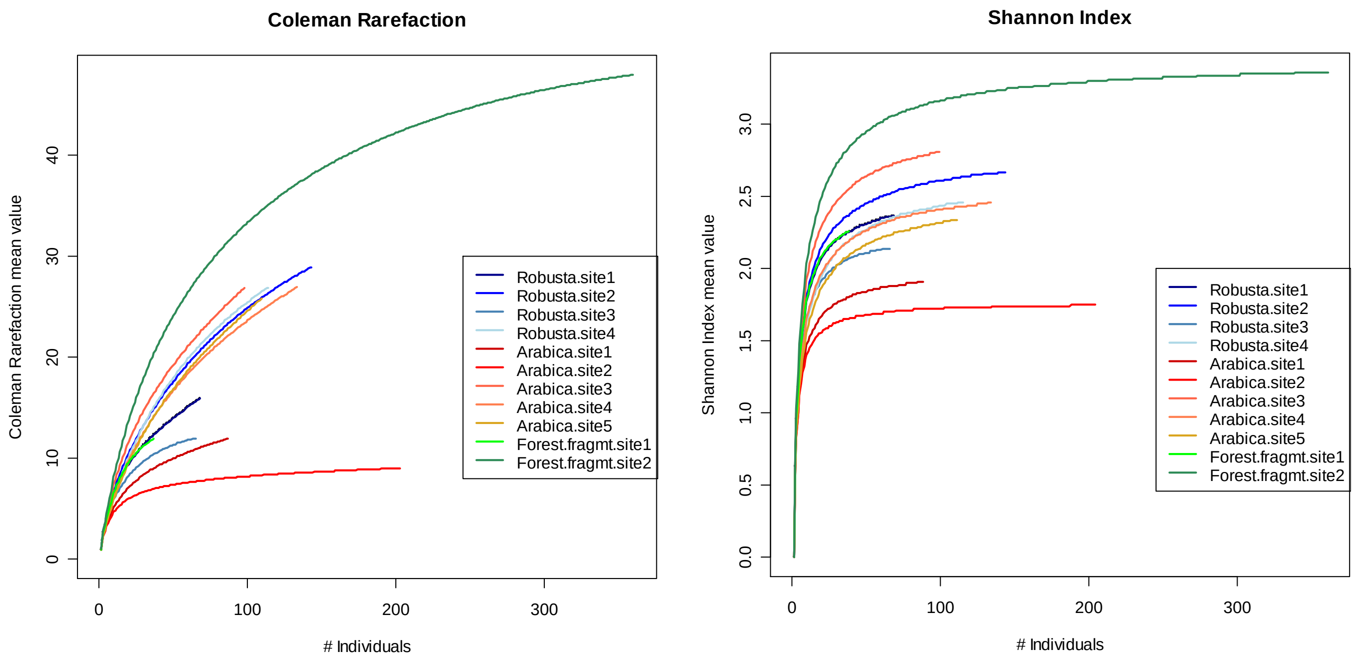
Tree Biodiversity Sampling Protocol: Variable width transects method (adapted from Sheil et al. 2002). A baseline is 40 m long, with 8 cells of 10 m width and variable lengths (noted d1 to d8). If there are no trees (cell #8) or less than 5 trees within 20 m (cell 5 and 6) of the baseline, the cell length is 20m (d5, d6 and d8). Else the length is the distance between the baseline and the fifth most distant tree. Each length is recorded and all trees within the cells included in the sample. In the figure the shadowed trees are excluded. We also indicate the location of the points for densiometer readings.



Densiometer reading point

Tree measured   Tree excluded

Box 2: Deciding a cut-off line (from Readme CAFNET INDIA Sampling Strategy.pdf)



Richness (Coleman rarefaction curves) and Diversity (Shannon Index) estimators across habitats (Fragmented forests, Robusta estates and Arabica estates) of the pilot study. Diversity indexes flatten sooner than richness. With a cut-off limit of 200 trees, we are confident we will be able to meaningfully describe differences in biodiversity patterns within the estates.

Results

Structure

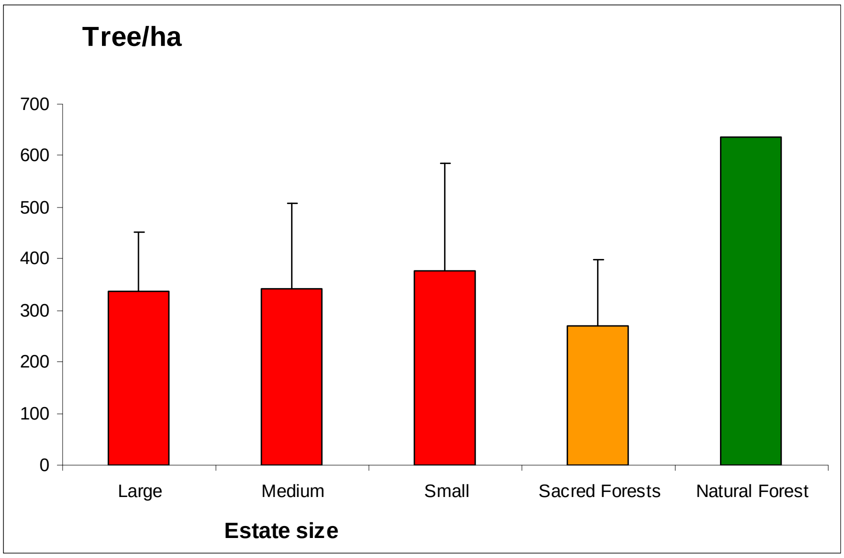


Figure 14: Tree density in the coffee states, sacred forests fragments and reference forests. The data from the forest fragments and the reference forest are drawn from Garcia, 2003.

The structure of the shade cover of the coffee estates in Kodagu is complex. The tree density is high, compared to remnant forest patches (for example *devarakadus*), and highly variable across estates (Figure 14). On average, coffee estates in the Kavery watershed have 350 trees per ha, compared to 270 Trees/ha in *devarakadus* and 640 trees/ha in the forest of the Brahmagiri Wildlife Sanctuary. The coffee estates of Kodagu are some of the coffee production systems with more trees on earth. The reasons behind this include the need to protect the floral buds against desiccation in case the blossom showers are late, the agronomic properties of the trees that improve the fertility of the soil and the specific land tenure and tree rights that constrain the management options of the farmers.

Composition

The coffee agroforestry system of the Kavery watershed contains a remarkably high biodiversity (Fig. 15). We identified close to 280 different tree species, and estimate the actual species richness to be close to 320 species. This is due to the fact that many of the trees of the original wet evergreen and moist deciduous forests have been conserved by the planters when they converted their land into coffee estates.

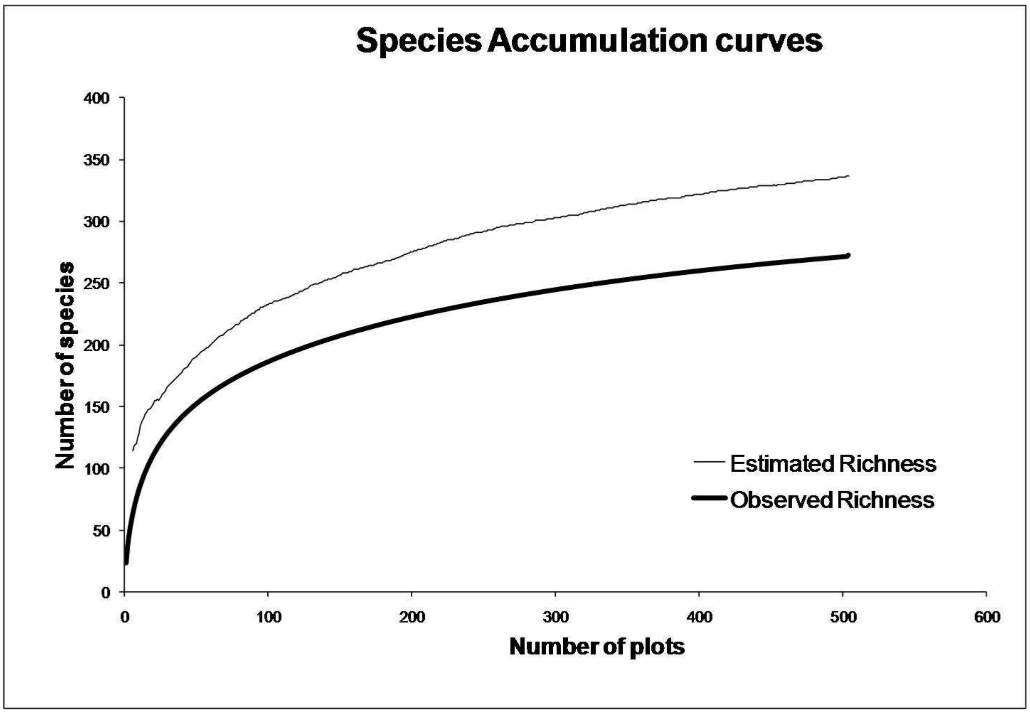


Figure 15: Species accumulation curves. As we keep adding plots to the sample, we keep identifying new tree species, until we have found most of the species present in the watershed. Through the use of a statistical estimator (ACE index, Chao & Lee 1992) we can estimate the number of species we have missed. The total number of tree species in the coffee agroforestry system of the Kavery watershed exceeds 320.

The species are not equally abundant (Fig. 16). One of them, Grevillea robusta (Silver oak) represents close to 20% of the trees of the watershed (that is one out of five). According to the farmers, there are 4 major reasons why Silver oak is preferred over native jungle wood species.

1. It grows fast
2. It provides a good stand for pepper
3. It has easily available seeds and seedlings
4. It is easy to fell, transport and sell.

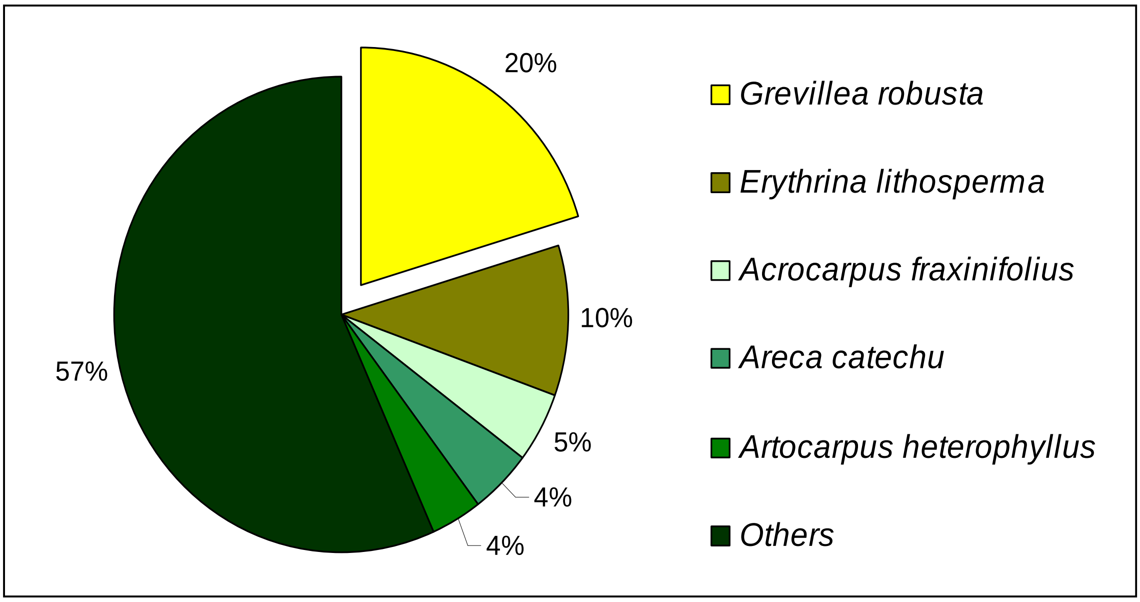
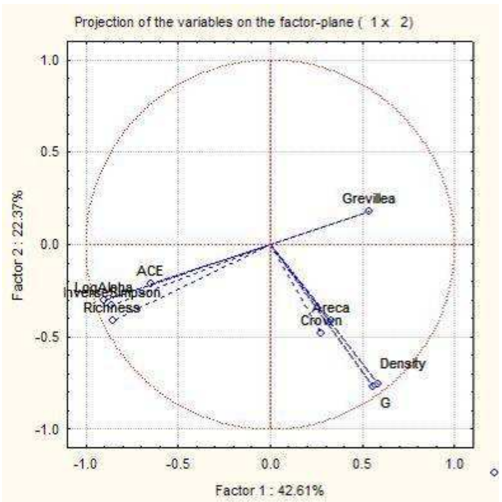


Figure 16: Distribution of tree species in the Kavery watershed. Total number of trees: 20 023. Percentages rounded to the nearest value. The five more frequent species are Silver Oak (*Grevillea robusta*), Dadup (*Erythrina subumbrans*), Balanji (*Acrocarpus fraxnifolius*), Arecanut (*Areca catechu*) and Jackfruit (*Acrocarpus heterophyllus*). The remaining 275 species are classified under Others and not shown here.

The drawbacks farmers attribute to the Silver Oak (slow decomposition of the litter, nutrient imbalance and leafs clogging the coffee bushes) are generally not sufficient to tip the balance in favor of the native tree species.



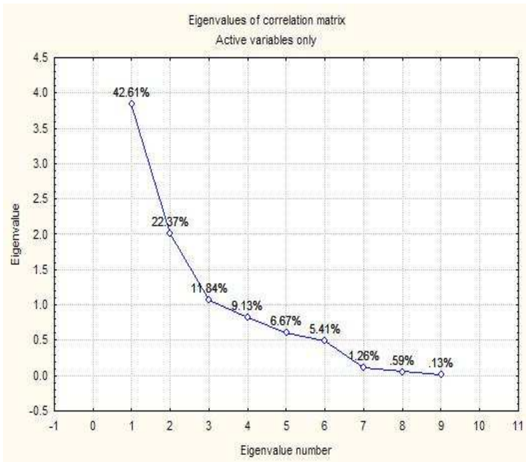


Figure 17: Principal Component Analysis results on the structure and biodiversity of the tree canopy of the coffee estates (515 transects).

A principal component analysis of the structural variables indicates that the percentage of *Grevillea robusta* in the coffee estate is negatively correlated to all the measures of tree biodiversity that we can produce. The second axis of the analysis opposes plantations with high levels of tree cover (density and basal area) to intensive plantations conducted with full sun coffee (Fig. 17).

The scree plot (right) indicates that the first two axis of the analysis extract 64% of the total variability. The second axis of the analysis opposes plantations with high levels of basal area and tree density to plantations without trees. The correlation plot (left) opposes the percentage of *Grevillea robusta* to all the biodiversity indicators.

Bird diversity

Birds are among the most studied groups in Ecology. Therefore, analyzing bird communities in the coffee agroforestry system of Kodagu provides a benchmark that can be used to compare this landscape to other coffee productions areas across the planet, as protocols are comparable. A first assessment of the bird communities was carried out with a sampling design matching the one of the tree canopy assessment. A second, more focused study, explores the possibility of using cavity-nesting birds as indicators of the shape and condition of the coffee agroforestry systems.

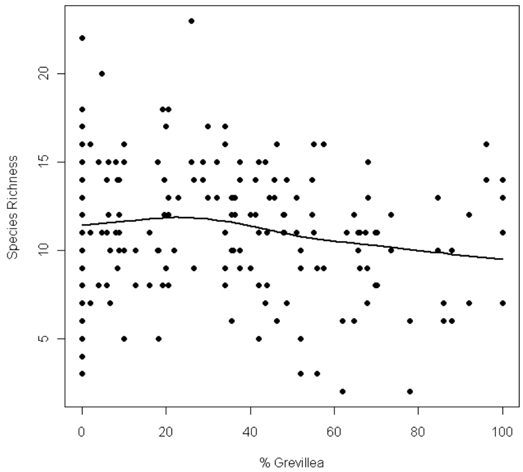


Figure 18: Impact of the Silver Oak on the bird species richness. Each dot in the graph represents one of the 114 plots where we monitored birds. The black line shows the relationship between the bird species richness (the number of different bird species identified in our sample) and the percentage of Silver Oak in the plot. It shows that when the proportion of Silver Oak trees exceeds 30%, the number of bird species diminishes.

The first bird diversity study was conducted to study the effect of tree composition on diversity of birds in the coffee estates of Kavery watershed area. In a subset of 115 tree biodiversity transects we conducted bird inventories, through point counts. The observation time was 15 minutes each, with morning and evening observations, and two consecutive campaigns in the same spot, 2008 and 2009. In addition to sightings and hearings, landscape features were measured on the spot. The 115 birding counts where randomly selected from the population of tree biodiversity transects, with a stratification based on the percentage of *G. robusta*, with three classes: (1) >40% *Grevillea*; (2) between 0 and 40% *Grevillea* and (3) 0% *Grevillea*.

The database comprises currently more than 3000 observations, and we have identified 109 species, 35 families and 12 orders of birds associated with the coffee agroforestry system. The most abundant species belong to the order Passeriformes. We have also identified indicator species that disappear from the coffee estates when the percentage of *G. robusta* increases.

Results indicated that the bird communities react negatively to high levels of *G.robusta*, with loss of richness and diversity. Intermediate levels however seem to increase biodiversity. As the proportion of Silver Oak increases in an area, the total number of bird species (Species richness) decreases (Fig. 18). However, this trend is observed only after the proportion of Silver Oak exceeds 20-30% of the trees in the location. This suggests that it is possible to retain Silver Oak in an estate, as it improves the revenue of the farmer, without damage to biodiversity, provided it is kept under a threshold (our data suggests 20-30%). This work was carried by V. Rao (UAS & FIP) and T.T.Hareesh (UASB). The report is accessible here: http://www.ifpindia.org/Managing-Biodiversity-in-Mountain-Landscapes.html

Figure 19: Seven of the 14 species of cavity nesting birds monitored in this study: (a) Dinopium benghalense ; (b) Hemicircus canente ; (c) Dryocopus javensis ; (d) Sitta frontalis ; (e) Psittacula columboides ;(f) Ocyceros griseus.

A second study concentrated on cavity nesting birds in coffee agroforestry systems as literature suggests that cavity-nesting birds are good indicators of the health of forested ecosystem. We tested this hypothesis in the coffee based agroforestry systems of Kodagu. Coffee plantations are modified at different degrees. Within the plantations, populations of wet evergreen and moist deciduous forest trees can be replaced partially to totally by *Grevillea robusta*. We studied the potential use of the cavity-nesting bird community (Figure 19) as an indicator of the state of coffee based agroforestry systems. We sampled 14 species across the watershed of the Kavery river, using a playback method, recasting prerecorded calls. This work was carried out in partnership with the research unit DYNAFOR from INRA Toulouse (Ursula Torres under the supervision of Dr. Gérard Balent). The data collection was completed in April 2010 and the final results presented in June 2010.

The presence of the cavity-nesting birds was correlated to the characteristics of the canopy stand and other parameters including landscape features and management of the coffee. We found that the species richness of cavity-nesting birds was positively influenced by the tree species richness and the average DBH (Diameter at breast height). The species richness of cavity-nesting birds showed a strong decrease with a percentage higher than 20 % of *Grevillea robusta* (Figure 20). The members of this community responded differently to the forest tree population's characteristics. The primary excavators were the most affected by the presence of *Grevillea robusta.* We concluded that cavity-nesting birds are good indicators of the biodiversity status of the coffee agroforestry system, but do not inform on the landscape features or the management of the coffee. The final report can be downloaded here: http://www.ifpindia.org/ecrire/upload/eco_projects/rapport_m2_torres.pdf

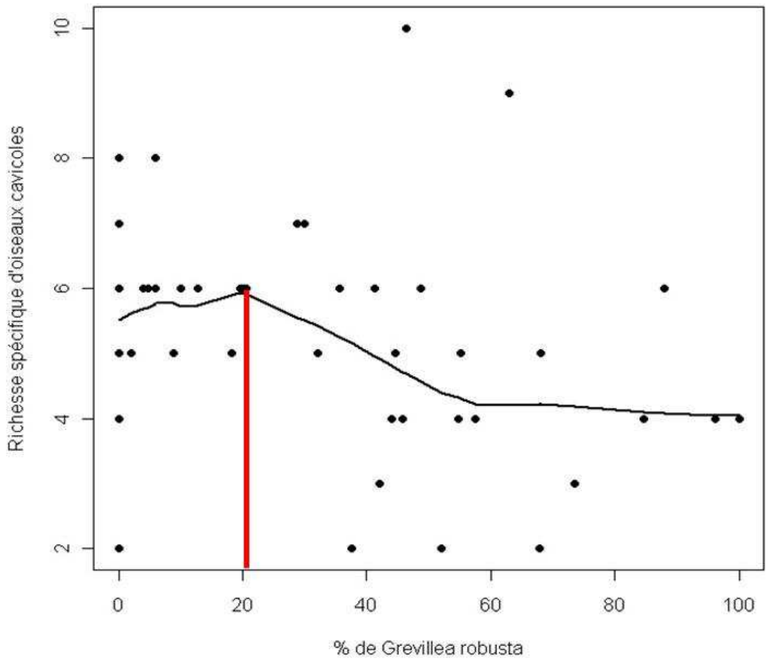


Figure 20: Impact of *Grevillea robusta* on the cavity-nesting bird species richness. As the percentage of *G.robusta* crosses the threshold of 20%, the species richness of cavity-nesting birds starts decreasing.

Epiphyte diversity

This component was undertaken on 36 farms (18 in evergreen and 18 in moist deciduous vegetation types) selected from the pool of CAFNET farms (see Tree Diversity Sampling Strategy) to assess the effect of tree diversity on epiphyte abundance and diversity in this coffee-dominated landscape. Epiphytes are one component of floristic diversity which affects the value of a plantation.

In this study, we examined the effects of tree composition on epiphytes by considering different variables such as canopy cover, tree diversity, tree girth class, and host specificity under two vegetation types, namely evergreen and moist deciduous. In total, 42 epiphyte species were recorded in evergreen and moist deciduous vegetations. Quantitative analyses were done to evaluate the effects of these variables on abundance of epiphytic species. The main results were:

1. The proportion of epiphytic species significantly increased up to certain thresholds of canopy cover (75%) after which it decreased.
2. Higher proportion of epiphytic species was recorded on host trees of girth classes (0.30 – 0.81 m) in both vegetation types. Since the density of trees was high in these girth classes, the results indicated that epiphytic species abundance increased with increase in tree size.
3. In Evergreen vegetation, *Syzygium cuminii*, *Oleo dioica*, *Terminalia bellirica* were the most common preferred hosts. In moist vegetation type, *Dalbergia latifolia* which was the most preferred host tree supporting much higher numbers of epiphytes than *Syzygium cuminii*, *Oleo dioica*, *Terminalia bellirica*. Even though these tree species host higher epiphytic species in evergreen vegetation but ranked after *Dalbergia latifolia* in moist deciduous vegetation types.
4. In total, 42 epiphyte species were recorded in evergreen and moist deciduous vegetations. *Pholidota pallida* and *Bulbophyllum neligherrense* were the most dominant epiphytes in both evergreen and moist deciduous vegetations. Following these three species, *Rhyncostylus retusa*, *Areides crispa, Liparis virdiflora,* and *Coelogyne breviscape* were the most abundant ones in Evergreen vegetation whereas *Cymbidium bicolor*, *Aspelium nides*, and *Ficus* spp. were other dominant epiphyte species in moist deciduous vegetation.

This study was conducted by Poornika Rani (UASB) as part of her Master degree in Forestry and thereafter as Junior Research fellow of the CAFNET project.

Microbiological studies

In the coffee ecosystem variations such as different shade management do occur. In the present investigation, it was proposed to compare soil microorganisms in different typologies of coffee production systems such as coffee with one specialized shade species, multistory coffee systems with 2 or 3 tree species and coffee with more than 3 tree species under moist deciduous and evergreen ecosystems. Soil samples were collected from coffee estates in different villages like Siddapura, Kudluchettalli, Kabbin Kadu, etc. Using a soil auger, 3 soil cores of 17 cm depth were collected from each sampling point. The 3 soil cores were mixed together to form a composite sample per sampling point. Total of 25 samples covering all the 3 typologies and 2 ecosystems were collected. Soil samples were transported to Bangalore and stored in a refrigerator.

Quantitative analysis of the total microflora:

Coffee plantation under evergreen ecosystem supports higher population of bacteria. Arabica coffee harbors more bacteria compared to robusta. Coffee grown under more than two shade tree species encountered higher bacterial population. Fungal population was higher in evergreen ecosystem. Coffee under more than 2 shade tree species harbored marginally higher fungal population. Number of actinomycetes was more in evergreen ecosystem, with robusta harboring higher number of actinomycetes. Coffee under mono shade tree species had higher population of actinomycetes.

Qualitative analysis of soil microflora:

a. **Nitrogen fixing bacteria**: The population of all groups of nitrogen fixing bacteria was enumerated by standard dilution plating technique using combined carbon medium. Nitrogen fixing bacteria were more than double in the evergreen ecosystem compared to deciduous ecosystem. Arabica coffee and coffee under mono shade tree species supported a slightly higher population of nitrogen fixing bacteria.

b. **Phosphate solubilising microorganisms**: The soil samples collected from different sampling points were used for enumeration of phosphate solubilising microorganisms by the standard plating technique using Sperber's hydroxy hepatite medium. Coffee grown under deciduous ecosystem had higher population of phosphate solubilisers compared to evergreen ecosystem. Arabica coffee encouraged more number of phosphate solubilisers. Population of phosphate solubilisers was less in coffee grown with single shade tree system compared to coffee with 2 or more shade tree species (Fig. 21).

c. **Cellulose decomposing microorganisms**: The number of cellulose decomposing microorganisms in the soil samples collected was determined by the standard plating technique using minimal nutrient agar medium containing Carboxy methyl cellulose. After incubation the plates were flooded with Congo red and 1M sodium chloride solution. Cellulose decomposers showed a clear hallow around their colonies. Cellulose decomposers were found to be higher in the deciduous ecosystem compared to evergreen ecosystem. Arabica coffee and coffee with 2 shade tree species had more cellulose decomposers in the root zone (Fig. 21).

d. **Lignolytic bacteria**: The thirty eight different types of bacteria which were isolated from coffee rhizosphere and maintained on nutrient agar slants were tested for their lignolytic activity. The bacteria were inoculated on to the ligno-sulphonate agar medium and incubated for 10days. Growth on the medium indicated that it is capable of utilizing lignin. Number of lignin decomposing bacteria was higher (23.5 %) in evergreen compared to deciduous ecosystem (4.7 %). Lignin decomposers were more in coffee grown under single shade tree species

e. **Starch hydrolyzing bacteria**: The starch hydrolyzing capacity of the isolated bacteria was tested by inoculating them on the starch agar medium. The plates were incubated for 3-4 days. A clear halo around the colony indicated the ability of the bacteria to hydrolyze starch. Starch hydrolyzing bacteria were higher in number (61.90 %) in coffee plantations grown in deciduous ecosystem and in coffee grown under 2 types of shade tree species (Fig. 21).

f. **Pectin utilizing bacteria**: The pectin utilizing capacity of bacteria isolated from coffee rhizosphere was studied by streaking the pectin medium with the isolate cultures and recording the presence or absence of growth after 7 days incubation. Population of bacteria capable of utilizing pectin was more in deciduous ecosystem (38.09 %) compared to evergreen ecosystem (17.6 %). Pectin utilisers were more in coffee grown under more than 2 types of shade tree species (Fig. 21).

g. **Antagonistic organisms**: The actinomycetes isolated were tested for their antagonistic activity against root pathogenic fungi by cross streak assay method. Among 14 actinomycetes tested 1 actinomycete isolate DAT2V1-1 (A14) showed antagonistic activity against root pathogen *Fusarium chlamydosporum* with inhibition zone measuring 12 mm (Fig. 21).

Figure 21: Analysis of microflora: The letters correspond to the analysis described in the text. (b Phosphate solubilising microorganisms; (c) Cellulose decomposing microorganisms; (e) Starch utilizing bacteria; (f) Pectin utilizing bacteria and (g) Antagonistic activity against root pathogenic fungi.

Conclusion

Coffee plantation under evergreen ecosystem supports higher population of bacteria, fungi and actinomycetes. Arabica coffee harbors more bacteria while robusta coffee harbors higher number of actinomycetes. Coffee grown under more than two shade tree species encountered higher bacterial population. Coffee under mono shade tree species had higher population of actinomycetes.

The number of infective propagules of AM fungi under evergreen ecosystem had higher inoculum potential of AM fungi. Of the 2 coffee types, arabica supported higher propagule numbers and coffee grown under 2 shade tree species resulted in higher number of infective propagules of AM fungi.

Lignin decomposing and nitrogen fixing bacteria were higher in coffee grown in evergreen ecosystem whereas cellulose decomposers, starch hydrolyzing and pectin utilizing bacteria were higher in deciduous ecosystem. Robusta coffee harbored higher number of lignin decomposing, starch hydrolyzing and pectin utilizing bacteria while cellulose decomposing microorganisms, nitrogen fixing bacteria and phosphate solubilising microorganisms were higher in arabica coffee. Lignin decomposers were more in coffee grown under single shade tree species, while starch hydrolysers were more in coffee grown under 2 types of shade tree species and pectin utilisers were more in coffee grown under more than 2 types of shade tree species.

Small mammals

In association with the University of Rhode Island, USA, the CAFNET team was involved in undertaking studies on impact of vegetation cover on the abundance and diversity of small mammals. In this pioneering study being undertaken for the first time in Coffee based agro forestry system in India, studies was completed in over 20 farms from February to June 2010. Farms were sampled each with two sets of 50- x 50-m trap grids. Each site was surveyed for 5 nights with the exception of the first site that was surveyed for 4 nights; yielding a total of 14,256 trap nights. The small mammals were trapped and released, after determining the species and taking measurements such as weight and length. Additionally, each of the twenty farms had one indirect sampling method grid which consisted of two track plates, two hair traps, and two digital camera traps (one flash and one infrared). The techniques used were approved by the University of Rhode Island's Institutional Animal Care and Use Committee as being the most humane treatment of animals possible. In addition, all trapping protocols were in compliance with the American Society of Mammalogists' guidelines.

The Kodagu Region is divided into three ecological zones: moist evergreen forest, intermediate rainfall region, and dry deciduous forest which corresponds to the rainfall zones high, transition, and low, respectively. Furthermore, each ecological zone can be sub-divided into three tree composition categories: predominately native forest, mix of native forest and nonnative trees, and predominately non-native or exotic trees. For this study, native is categorized as 0-30% of *Grevillea robusta*, mixed 31-49% *Grevillea robusta*, and exotic as over 50% *Grevillea robusta*. Therefore, there were nine different categories of coffee habitat to evaluate (rainfall zonetree composition): high-native (1), high-mixed (2), and high-exotic (3); transition-native (4), transition-mixed (5), and transition-exotic (6); and low-native (7), low-mixed (8), and low-exotic (9).

During the four-month study period, there were 146 overall captures (1.02% trap success rate) and 129 individual captures (0.90%) for the Sherman traps. The Tomahawk traps yielded no capture for the study period. The capture rates per grid site were low; ranging from 0 to 3.89% for overall captures and 0 to 3.61% for individuals. Because the number of trap nights differed in each category, the data are standardized using a1000-trap night base.

A total of six different species were captured: *Bandicota bengalensis* (Lesser Bandicoot Rat), *Funambulus tristriatus* (Western Ghats Striped Squirrel, Jungle Palm Squirrel), *Mus booduga* (Little Indian Field Mouse), *Mus musculus* (Common House Mouse), *Rattus wroughtoni* (Common White-bellied Rat), and *Suncus murinus* (Grey

Musk Shrew). Of these species only *Funambulus tristriatus* is endemic to the Kodagu region. Over 50% of all captures were *Rattus wroughtoni*, followed by *Funambulus tristriatus, Rattus wroughtoni* (Common Rat), *Bandicota bengalensis* (Lesser Bandicoot), *Suncus murinus* (House Shrew).

Figure 22: Three of the captured species of small mammals: (a) *Rattus wroughtoni* (Common Rat); (b) *Bandicota bengalensis* (Lesser Bandicoot); and (c) *Suncus murinus* (House Shrew).

Figure 23: Medium sized mammals from camera traps: (a) *Sus scrofa* (Wild Pig) and (b) *Viverricula indica* (Small Indian Civet).

Human Elephant Conflict

The district's forests (46% of the total area) harbor a large population of Asian elephant (*Elephas maximus*). The combined effects of high elephant density and large scale landscape changes due to the expansion of coffee cultivation have resulted in an increase in the intensity of human–elephant conflicts (HEC) in the district. Mitigation strategies, including electric fences and compensation schemes implemented by the Forest Department have shown limitations. Building on previous studies in the area, CAFNET assessed the current spatial and temporal trends of conflict and analyzed local stakeholders' perceptions, trying to identify the factors driving elephants into the estates.

Methods

We collected records from the Karnataka Forest Department, detailing crop damages by elephants and compensation claims made by farmers between 1996 and 2007. The records were obtained from Deputy Conservator of Forests (DCF) offices of Virajpet, Madikeri and Hunsur, including data for some of the villages adjoining Rajiv Gandhi (Nagarahole) National Park (NNP) and Brahmagiri Wildlife sanctuary (BWS) from the Hunsur Wildlife Division office. During May - July 2007, we conducted interviews with estate owners, corporate estate managers, forest watchers, Eco-Development Committee (EDC) and Village Forest Committee (VFC) members, estate workers, tribal inhabitants and local experts (total: 18) to learn the local perceptions on the causes of Human-Elephant Conflict, crops damaged, coping strategies developed locally and the role of the local stakeholders. During February – April 2008 we also studied the consumption of ripe coffee berries by elephants by recording the location of all dung piles observed (209) and counting the coffee seeds therein.

Results

Temporal and Spatial Trends

The number of crop damage cases varied widely from year to year between 1996 and 2007 (Fig. 24). The change in number of cases over time was not linear, but there is nonetheless an increase of crop damage cases with the passing of time, especially due to the substantial increase during 2005-2007. There was no significant correlation between the number of crop damage cases and quantity of rainfall or number of rainy days.

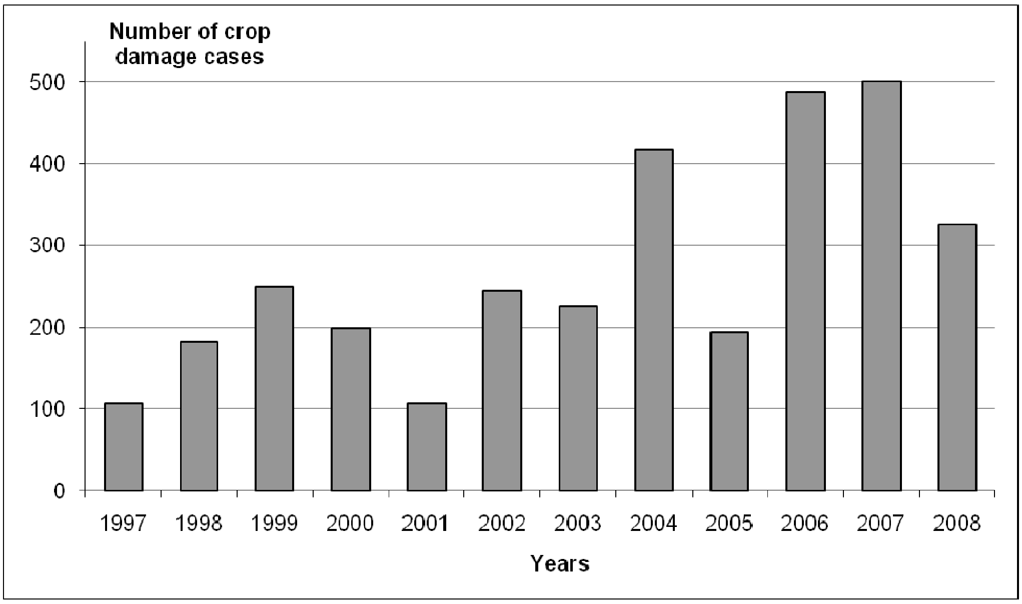


Figure 24: Number of crop compensation cases recorded in the Virajpet division between 1996 and 2008 (3,240 reports). The trend indicates a statistically significant increase in the number of compensation files, in turn suggesting an increase in the number of crop raiding cases.

The mean annual number of crop damage incidents plotted on a map of Virajpet Division showed varying intensity of conflict across villages (Fig. 25). The region of highest conflict was the northeastern part of the division. Conflicts also occurred along all forest boundaries. It is possible that some of the villages adjoining Nagarhole National Park and Brahmagiri Wildlife Sanctuary suffer from higher intensity of conflict than are apparent in our map due to a few missing datasets. The central band of higher conflict between the east and west forest belts, with adjacent areas showing zero conflict, suggests a corridor of elephant movement already reported by previous studies (Nath & Sukumar 1998). Annual crop damage maps showed this band in at least 3 of the 12 years examined. This suggests a seasonal, though not systematic, migration between the eastern and western sides of the district through this route, following the southern ridge of the Kavery river watershed.

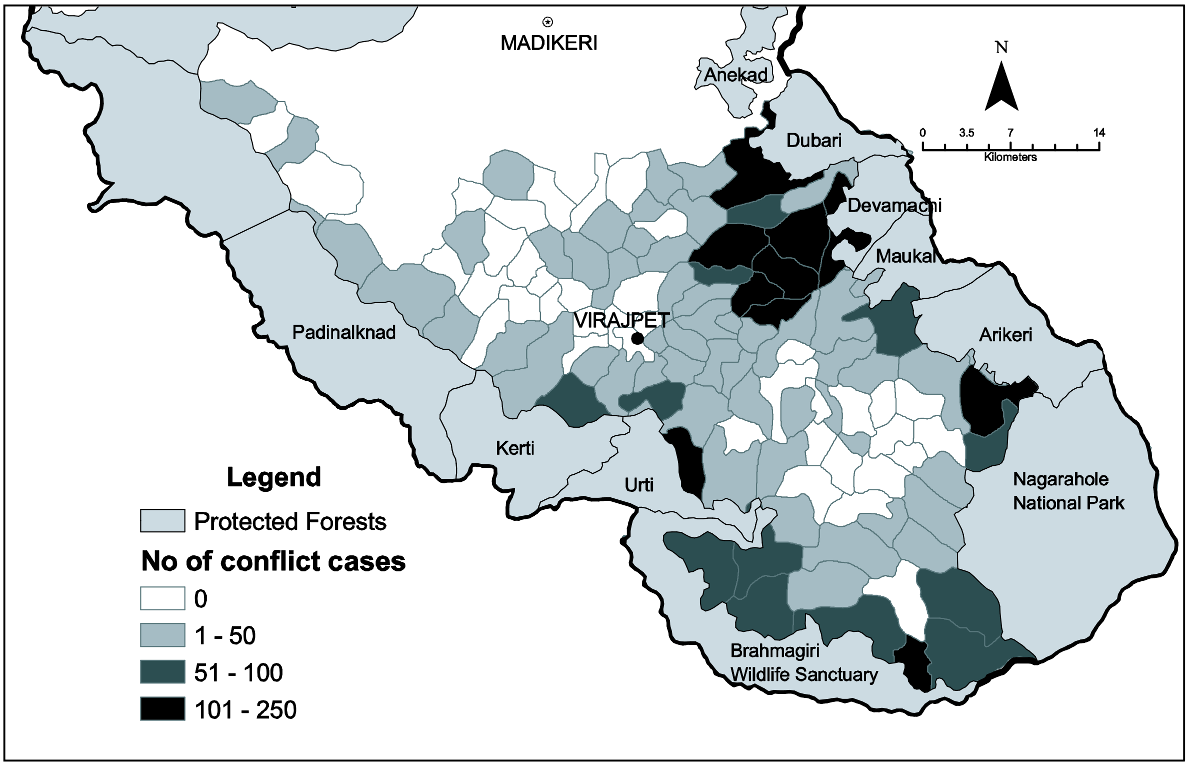


Figure 25: Spatial map of HEC in Virajpet Division, showing total incidents registered per village during the 12 years from 1996/1997 to 2007/2008 (3,240 reports).

Stakeholders Perception

Data from interviews suggest that elephant visits to estates are an old phenomenon. Still, half of the respondents claimed that HEC had increased in Virajpet since 1997. For 16% of them, the problem was only 5 years old. This significant portion suggests that newer areas were becoming part of the conflict zone. According to the respondents, the rise in HEC stems from four reasons: (1) the forest has insufficient resources to sustain the large elephant population; (2) elephants are exhibiting new behavioral patterns; (3) their original habitat has experienced degradation; and (4) the local elephant population has increased (Fig. 26).

Interviews highlighted discontent from all residents, especially farmers, with the KFD's attitude towards conflict mitigation. Some farmers acknowledged the KFD lacked staff and infrastructure to deal adequately with the problem, but also blamed the institution for inadequate maintenance of the solar fences (SF) and elephant-proof trenches (EPT). They also mentioned the lack of fast or adequate help to the affected farmers. Some respondents felt that the KFD lacked transparency in its decision making and experienced no effective dialogue with the agency.

Interviews also refer to changes in the landscape. The area under coffee cultivation has doubled in Kodagu district over the last 30 years (See handout on Trees and Biodiversity; (Garcia et al. 2009). The coffee agroforestry system offers highly palatable, densely packed and easily accessible resources including fruit trees, paddy, grass, and water. Further changes in land use, dams and forest fires have caused habitat fragmentation and disruption of elephant migratory routes.

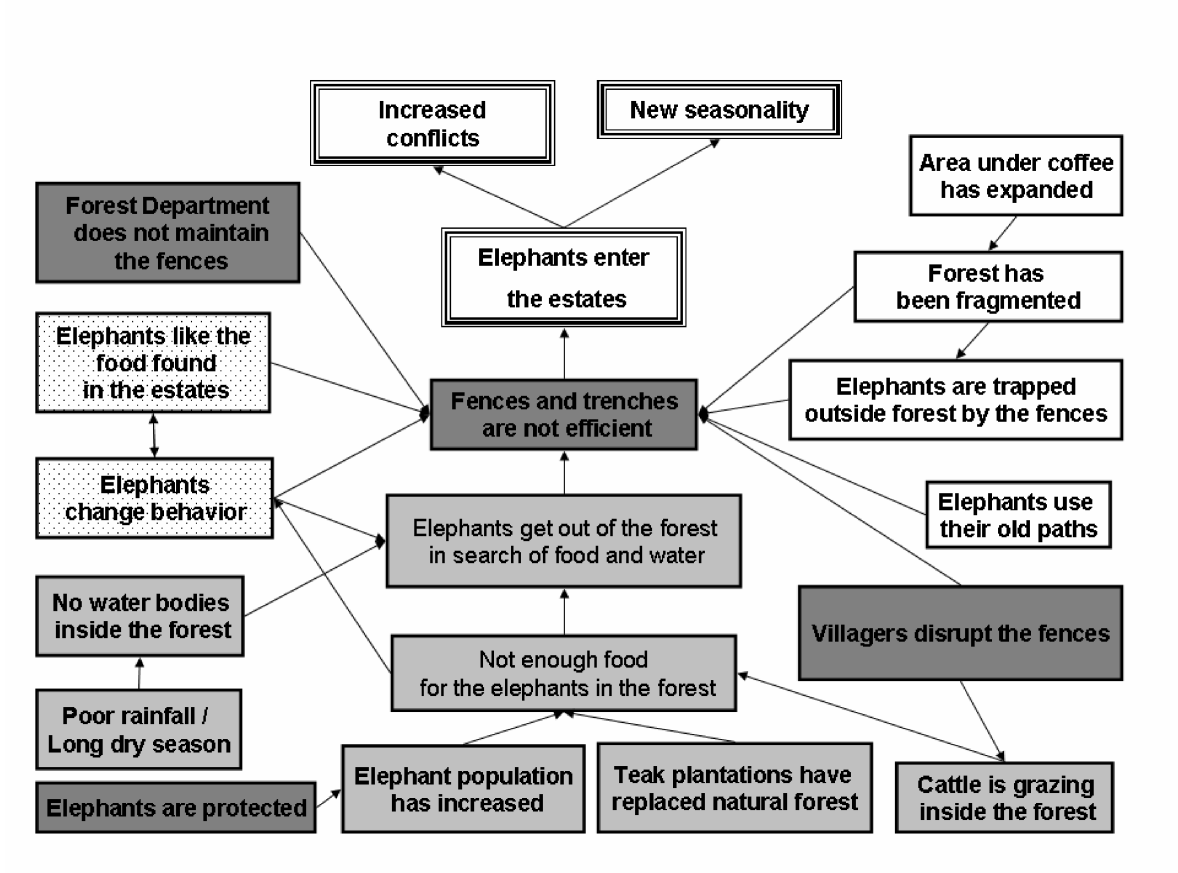


Figure 26: Problem Tree "Why do elephants enter the estates?" based on stakeholders' perceptions. The perceived causes of the problem can be classified into (1) available resources (light grey), (2) stakeholder's coordination (dark grey), (3) spatial structures of the landscape (white) and (4) elephant behavioral traits (dotted).

Coffee Berry Consumption

We found a high proportion (0.64) of dung piles contained coffee seeds. More than 50% of the total sample had >50 coffee cotyledons (Fig. 27), suggesting ripe coffee berries were part of the diet of the elephants in the area. We did not find significant differences between age groups (determined based on the size of the dung pile) suggesting adults and juveniles both ingest coffee ripe berries. This is, to our knowledge, the first report of wild elephants feeding on coffee berries. Coffee berries in Kodagu ripen between December and February, earlier for Arabica, later for Robusta. Coupled with the peak of damage to coffee bushes in February, the presence of seeds in the dung indicates that coffee itself is attracting the elephants, creating a new seasonal pattern.

Even if currently confined to a few individuals, this novel behavior could rapidly spread through the local population via cultural transmission and learning. Were that to happen, it could compound an already severe conflict situation due to the high economic value of coffee.

Figure 27: Elephant dung containing coffee seeds. The amount of seeds and the number of dung piles containing coffee seeds indicate it is not accidental consumption

Discussion

CAFNET documents a trend of increasing conflict, with new seasonal patterns and new elephant behaviour that will affect local stakeholders negatively in the years to come.

Each solution tried to date has been more or less acceptable to different stakeholders rather than objectively good or bad. Solar electric shock fences may have reduced elephant intrusions, but they have also prevented cattle from grazing in the forest, benefiting some stakeholders but inconveniencing others. They also require funding and a labour force to maintain them. When the Forest Department launched a capture and relocation programme, it lost animals due to stress or misestimated tranquilizer dosages (Gandhi 2009). In short, no amount of technical expertise is likely to solve this problem. Each solution will entail costs and lead to unexpected consequences, and may even worsen the problem. These relative failures coupled with discontent regarding the compensation scheme have directly translated into stakeholder distrust which is liable to hinder any future strategy proposed.

Resolving HEC in Kodagu requires a combination of deterrent, compensating and tolerance-raising strategies with better stakeholder involvement. The decision makers need to develop an integrated approach, sifting through the multitude of potential solutions to find a combination of techniques that will reduce damage to tolerable levels.

None of these techniques is new. A crop insurance scheme could be more efficient than the current compensation system if farmers were involved in developing the scheme's modalities. The conflict map (Fig. 13) could help frame priority intervention areas or devise insurance rates, with costs commensurate with farmers' threat perception and risk aversion. A landscape-level labelling or elephant-friendly coffee label, (Aane kaapi, 'elephant's coffee' in Kannada) similar to the bird-friendly coffee label of the Smithsonian Institute, could help raise the tolerance level within the local population. This scheme could build upon the iconic value elephants have at local and international levels. The fact that elephants have started feeding on coffee could even be used to attract consumer attention. Such a scheme could either secure a premium price for products marketed with this label or secure market access. If farmers obtain a tangible benefit from the presence of elephants in their estates, the problem may cease to be perceived so negatively.

We believe that stakeholders in Kodagu need to be aware of the nature of the problem they face, lest they grow increasingly disheartened as failures accumulate and mistrust between stakeholders becomes entrenched. The problem will only be solved when the local society decides that the perceived benefits derived from the presence of the elephants outweigh the perceived damage they cause. Better transparency in decision making and solutions that increase public tolerance of elephants through direct benefits are thus needed.

This work, led by the FIP, was carried out by Payal Bal. The results have been published in a report (Bal et al. 2008) accessible here: http://www.ifpindia.org/ecrire/upload/reports/bal_2008.zip and in a peer-reviewed journal (Bal et al. 2011).

Activity 2.3 Environmental Impact Assessment of Coffee Agro-forests

Hydrology

One key service identified by local stakeholders relates to water provision, a critical issue since the main rivers that are providing water for urban centres and agriculture all over Southern India, are all originating from these coffee areas of the Western Ghats.

Over the last 30 years, coffee cultivation has been expanding tremendously in the region (from 15% to 32% of the total area in Kodagu) to the detriment of forest. Still, both Robusta (80%) and Arabica (20%) are grown under the shade of multi-strata agroforestry systems (AFS) and hence play a major role in biodiversity conservation and provision of goods and services for the local and global communities.

The tree composition of this coffee agroforestry landscape has been profoundly affected by important changes in management practices such as irrigation to stimulate coffee mass flowering and introduction of fast growing tree species (mainly *Grevillea robusta*, called locally "silver oak") for timber production and stand for pepper.

Consequently, the CAFNET team in India studied for 3 years how the change in tree cover from predominantly native tree species to exotic species (mainly silver oak) was affecting the water dynamics in the coffee agroforestry systems in the Kavery watershed of Kodagu district, the most important coffee district of the region.

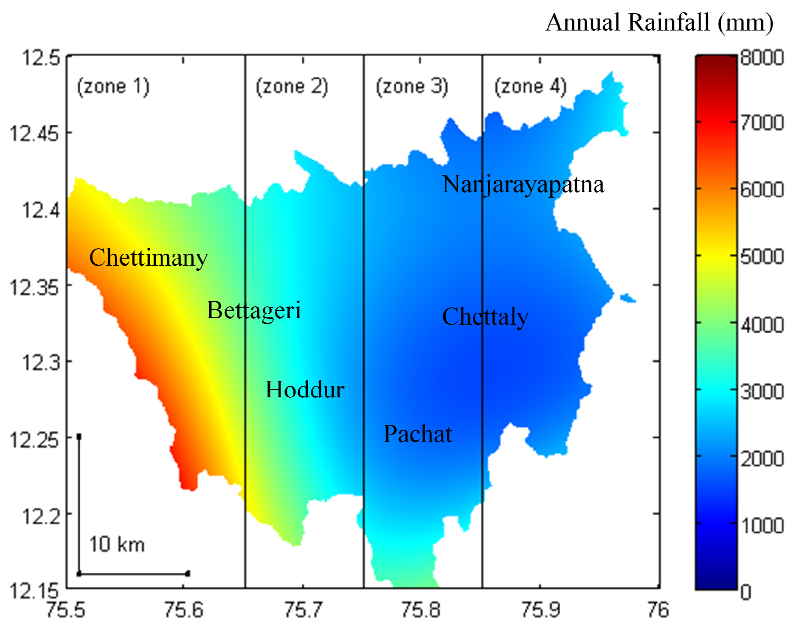


Figure 28: Geographic position of the 6 hydrological sites in the Kavery watershed.

During 3 years (2008-2010), six sites were selected in terms of rainfall regime along the West-East transect (Deciduous Eastern zone: ~40-70 inch/year; Central zone: ~70-110 inch/year; Evergreen Western zone: ~110-200 inch/year) in the Kavery watershed, the central watershed of the Kodagu district. In each site, 2 adjacent plots (less than 200 m apart) were selected, one predominantly composed of native tree species and one predominantly composed of silver oak, the main exotic species.

Only data of 3 sites are presented in this report; the two extreme ones with respect to rainfall regimes (Nanrajayapatna in Deciduous Eastern zone: ~40-75 inch/year and Chettimani in Evergreen Western zone: ~200 inch/year) and the one in the centre (Pachat in Central zone: ~70-120 inch/year) of the Kavery watershed (Fig. 28).

Main characteristics of these 3 sites are presented in Table I. Basal area of coffee plants is higher in the Central site due to the fact that coffee plants were much older (and hence with larger trunks) than coffee in other sites. Coffee leaf area indexes (LAI) were all in the range of 1.8-2.5 for the maximum values and 0.9-1.7 for their minimum values.

Shade trees density varied greatly from site to site with values as low as 160 trees per ha in the Native plot of the Eastern site to 1210 trees in the Exotic plot of the Western site (see Table I).

In spite of this, values of tree basal area were in a closer range of 10-35 m^2/ha and tree LAI even more so with values of 0.9 to 1.7. Species composition of shade cover varied from 60% of silver oak in the Exotic plots and from 54 to 99% of native species in Native plots, hence providing contrasted shade cover compositions.

Table I. Density (Nb/ha), basal area (m^2/ha), leaf area index (LAI) of coffee plants and shade trees and % of silver oak in the shade composition of plots with predominantly native tree cover (Native) or predominantly exotic tree species (Exotic) in the Western, Central and Eastern zones of the Kavery watershed.

Site	Plot	Coffee			Shade Trees			
		Density (Nb/Ha)	Basal Area (m^2/Ha)	LAI (Max-Min) (m^2/Ha)	Density (Nb/Ha)	Basal Area (m^2/Ha)	% silver oak (%BA)	LAI (rainy season) (m^2/Ha)
Western	Exotic	1120	2.9	2.2 – 1.6	1210	20	61%	1.5
	Native	1420	3.0	2.1 – 1.5	650	14	1%	1.0
Central	Exotic	1110	7.3	2.2 – 0.9	500	27	66%	1.7
	Native	650	19.5	1.8 – 1.2	500	35	46%	0.9
Eastern	Exotic	1120	4.3	2.4 – 1.7	430	19	60%	0.9
	Native	1560	8.3	2.5- 1.7	160	10	10%	1.0

Throughfall is the amount of rain arriving directly to the soil surface without being intercepted by coffee and tree canopies. Throughfall values were in the range of 71-91% (Table 2). In the Western site, throughfall of the Exotic plot represented 71% of total rainfall compared to 78% for the Native plot, which means that more rainfall arrives to the soil in the Native plot than the Exotic one.

In the Central site, throughfall of the Exotic plot was also lower (87%) compared to the Native plot (91%). In the Eastern site, values of throughfall were very similar (78%-81%) in the Exotic and Native plots. Consequently, no definitive trend could be observed on the effect of increasing proportion of silver oak in the shade cover composition on rainfall interception due to the fact that rainfall interception by trees (1-6%) was small compared to that of coffee trees (9-22%).

Figure 29: Collecting rainfall data.

Stemflow is the amount of rain intercepted by the canopy that flows along the trunks to the soil surface. Stemflow values of coffee and trees were small, usually at less than 5%, and hence can be considered as negligible.

Table II: Rainfall, throughfall, coffee stemflow (Coffee SF), tree stemflow (Tree SF), rainfall interception of system (coffee + tree) and of tree canopy alone, and runoff in native and exotic plots of the three sites (Eastern, Central and Western) of the Kavery watershed. Components are expressed as percentages of total rainfall for the monitored period (June 2009 to April 2010).

Site	Plot	Total Rainfall mm (inch)	Throughfall %	Coffee SF %	Tree SF %	Interception System	Interception Trees	Run-Off %
Western	Exotic	3 529 (140)	71%	0.3%	5.0%	25%	3%	4.0%
	Native		78%	0.3%	2.9%	20%	4%	5.0%
Central	Exotic	2 012 (80)	87%	0.4%	2.9%	18%	5%	5.2%
	Native		91%	0.5%	2.0%	15%	6%	5.7%
Eastern	Exotic	1 024 (40)	78%	0.6%	3.1%	22%	1%	3.8%
	Native		81%	1.0%	1.7%	19%	4%	3.4%

Runoff is the amount of rain flowing at the soil surface and not penetrating into the soil, hence responsible for soil erosion. Runoff was comparable between plots on the same site and low in the range of 3-6% due to the fact that 1) slope was not steep (<5%) in the monitored sites, 2) coffee and shade tree LAI was high with a low proportion of rainfall directly arriving to the soil, and 3) soil was abundantly covered with leaf litter.

asuring runoff.

The monitoring of coffee and shade tree **transpiration** was performed only in the Central site, but coffee and tree transpiration can be extrapolated for the entire Kodagu district from climate data gathered in the 5 other sites. Coffee under shade of native trees transpired more than coffee under shade of exotic tree (mainly silver oak) during all the seasons (Fig. 31) with comparable LAI (Table I). This indicates that coffee plants under native trees were less water limited (or less water stressed, especially at the middle and end of the dry season) than coffee under shade of silver oak.

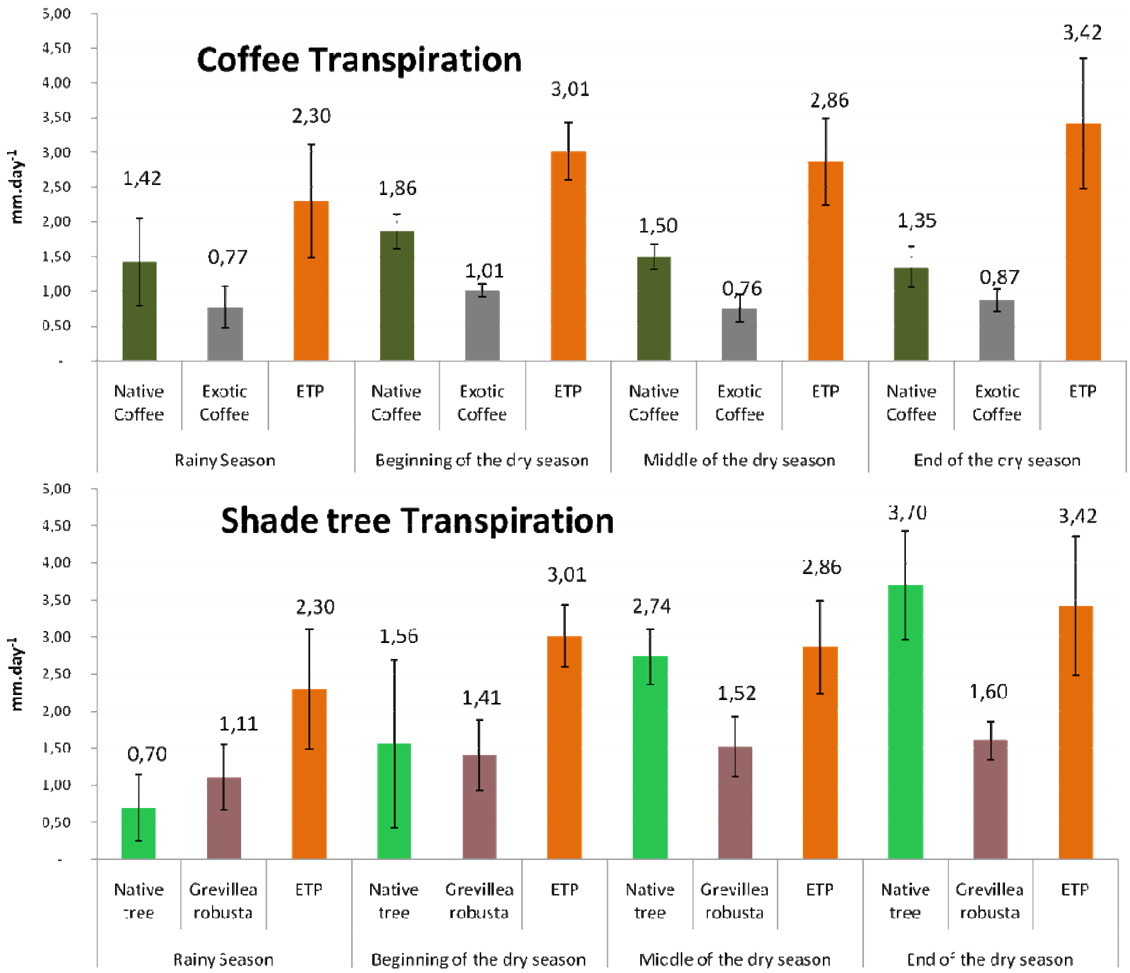


Figure 31: Transpiration of coffee plants and shade trees during the rainy season and the beginning, middle and end of the dry season compared to the evapo-transpiration potential (ETP).

During the rainy season and at the beginning of the dry season, native trees transpired less than exotic trees (mainly silver oak) probably due to their fast growth.

In the middle and towards the end of the dry season, native trees transpired more than silver oak which was probably due to the fact that native trees were older and more-deeply rooted than silver oak, and they can access soil water at deeper depth than silver oak.

'e 32: Measuring soil water profile

Soil water profile and water content over time

Water content in the soil (down to 1.6 m depth) was monitored every 15 days on the 6 sites, but is shown here only for Pachat as a representative example. It can be seen that the soil water content did not differ much between the native plot and the exotic plot from the rainy season to the dry season (Fig. 33).

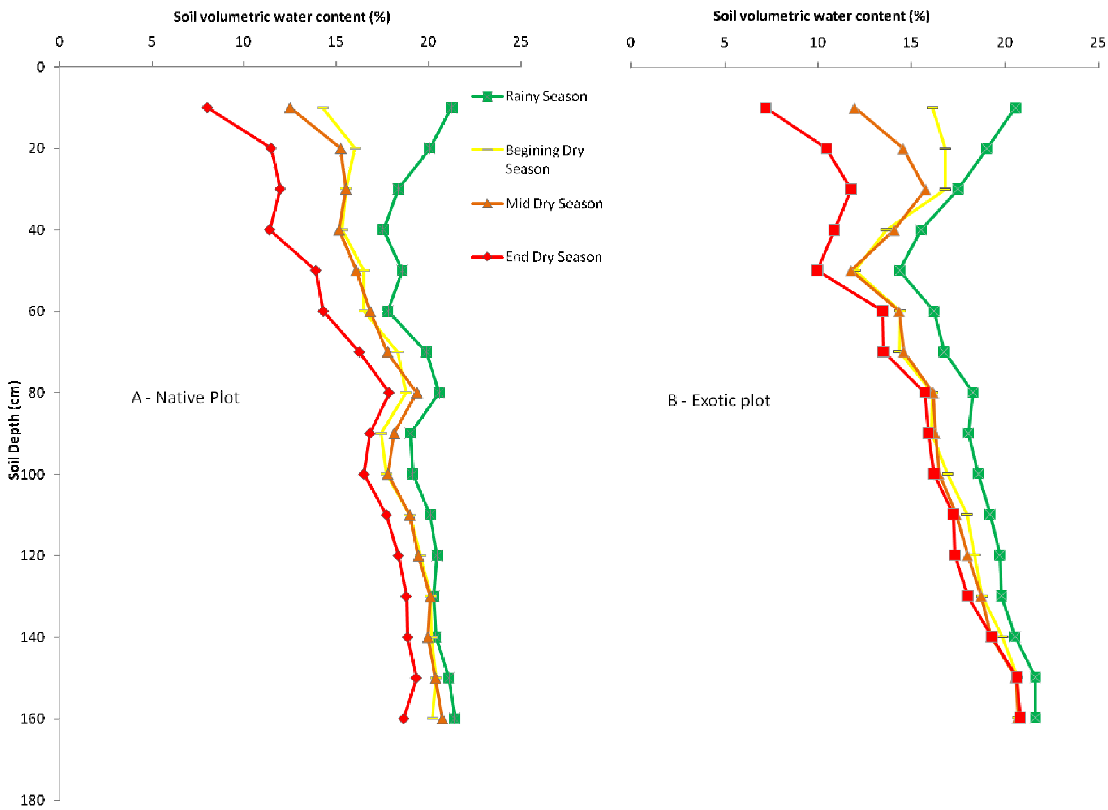


Figure 33: Soil water content down to 1.6 m depth in the native and exotic plots of Pachat during the rainy season and and the beginning, middle and end of the dry season.

At the end of the dry season, it can be seen that the soil water content appeared to be lower in the native plot than in the exotic plot and this is probably related to the fact that coffee and shade trees transpired more in the native plot with native trees taping water at lower soil depth due to their deep root system.

Water recharge

The amount of rain infiltrating into the soil was usually greater in native plots than in exotic plots especially in the Western and Central zones where there was a lot of rainfall (Table III). However, the amount of water drained below the main root zone (i.e. 1.6 m depth) was lower in the native plots than in the exotic plots (Table 3). This is essentially due to the fact that the transpiration of coffee and native trees (called system transpiration) was higher than that of coffee and exotic trees particularly during the dry season as shown on Fig. 31). Therefore, there is less amount of water from native plots going to rivers and recharging the aquifers than from the exotic plots. In the Western zone, there was around 300 mm (838-567) or 12 inches less water drained below the root zone in the native plot than in the exotic plot. There was about the same difference (781-480 mm) in the Central zone. The difference was less with around 120 mm (219-93 mm) or 5 inches in the drier Eastern zone.

Table III: Total rainfall, net rain infiltration into the soil, coffee transpiration, shade tree transpiration and total system transpiration (coffee + tree) and estimated drainage in native and exotic plots of the three sites (Eastern, Central and Western) of the Kavery watershed. Components are expressed in mm of rainfall for the monitored period (June 2009 to April 2010).

Site	Plot	Total Rainfall Mm (inch)	Net rain Infiltration mm (inch)	Coffee Transpiration mm (inch)	Shade tree Transpiration mm (inch)	System Transpiration mm (inch)	Deep Drainage mm (inch)
Western	Exotic	3 529 (140)	1 610 (63)	287 (11)	484 (19)	771 (30)	838 (33)
	Native		1 925 (76)	581 (23)	777 (30)	1 357 (53)	567 (22)
Central	Exotic	2 012 (80)	1 499 (59)	267 (11)	541 (21)	718 (28)	781 (31)
	Native		1 630 (64)	492 (19)	658 (26)	1149 (45)	480 (19)
Eastern	Exotic	1 024 (40)	537 (21)	118 (5)	200 (8)	318 (13)	219 (9)
	Native		601 (24)	217 (9)	290 (11)	508 (20)	93 (4)

The main conclusions of this hydrological study are:

- Canopy of coffee and shade trees intercepts 15-25% of the rainfall, which means that only around 75-85% of the rainfall arrives at the soil surface. Furthermore, coffee trees intercept the largest part of the rainfall (9-21%) whereas shade tree intercepted much less (1-6%), hence the effect of increasing proportion of silver oak in the shade cover composition does not appear to be so important on rainfall interception,
- Coffee under shade of native trees transpires more than coffee under shade of exotic tree (mainly silver oak) during all the seasons but particularly more during the dry season,
- Native shade trees transpire more than silver oak, especially during the dry season,
- Runoff is comparable (in the range of 3-6%) in native and exotic plots,
- The amount of rain infiltrating into the soil is greater in native plots than in exotic plots especially in the Western and Central zones where there is a lot of rainfall,
- The amount of water drained below the main root zone (i.e. 1.6 m depth) is lower in the native plots than in the exotic plots due to the fact that coffee and native trees transpire more, and hence there is less water from native plots going to rivers and recharging the aquifers than from the exotic plots.

Two graduate students of UASB actively participated to hydrological research as part of their MSc theses. Two scientific articles are in the process of being published on these results in international journals.

Historical rainfall records by coffee farmers

Many farmers interviewed by the CAFNET team during collection of local knowledge are convinced that rainfall pattern has changed over the last decades with the annual amount of rainfall decreasing and that it is affecting their coffee production. Rainfall is of course very important for coffee flowering and production.

The most important climate characteristics of the Western Ghats region and hence the target watershed of the CAFNET project are 1) the south-west monsoon which concentrates annual rainfall into a short period of 5-6 months (June to October) and 2) the strong rainfall gradient with annual rainfall decreasing in less than 50 km from over 5000 mm (~200 inch/year) in the Evergreen Western part to 1200 mm (~50 inch/year) in the Moist Deciduous Eastern part.

Local stakeholders are also becoming more and more aware of the importance of the Western Ghats region (and hence the coffee systems with high tree cover) in terms of water provision as all the main rivers providing water for urban centres and agriculture in Southern India all originate from the coffee areas of this region. Conflicts between rural communities and states of Southern India are becoming more frequent on this water issue.

Thanks to the valuable collaboration of over 80 farmers in the Kavery watershed, the CAFNET team in India was able to gather, produce maps and analyse rainfall data registered by farmers for decades as shown for the year 2002 on Fig. 34. It is important to emphasize that rainfall data were collected every rainy day for over 70 years in some of these farms.

This has allowed the CAFNET team to assess how the rainfall pattern has changed in this watershed over the last decades and also helped in predicting future rainfall.

These rainfall data show that there is **a very strong annual rainfall gradient in less than 50 km** in the Kavery watershed, the central watershed of the Kodagu district. Indeed, annual rainfall decreases very rapidly from the Evergreen Western zone (Zone 1), very wet with 5000-4000 mm/year (~200-150 inch/year) to the West-Central Zone (Zone 2) with 4000-3000 mm/year (~150-120 inch/year) to the East-Central Zone (Zone 3) with 3000-2000 mm/year (~120-80 inch/year) and to the drier zone, the Moist Deciduous Eastern zone (Zone 4) with 2000-1200 mm/year (~80-50 inch/year).

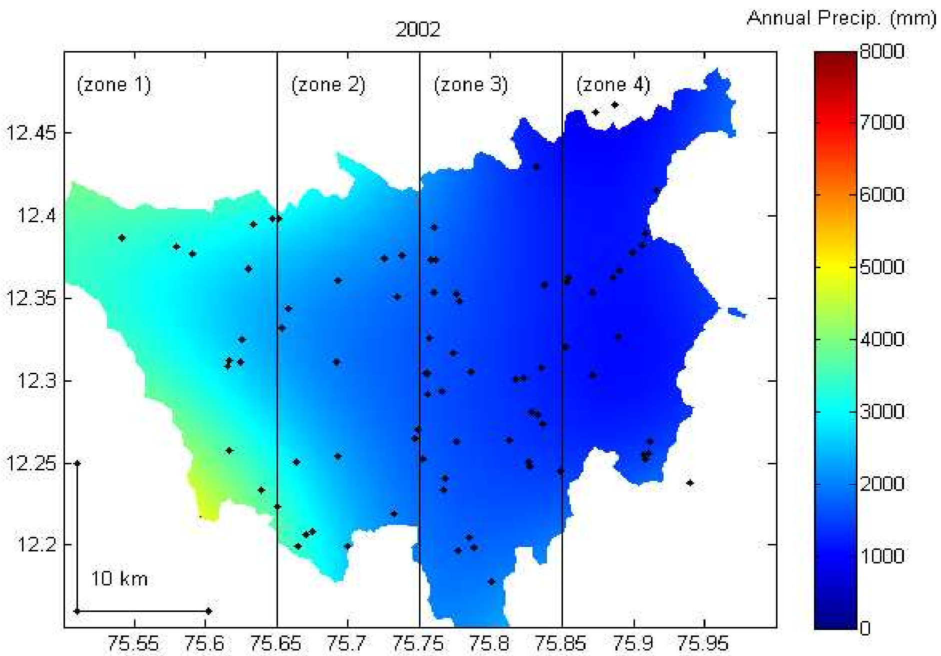


Figure 34: Geographic position of the farms where rainfall data were collected daily by farmers up to 70 years and map of rainfall distribution generated with these data as an example for the year 2002.

The analysis also shows that there is **a strong fluctuation of annual rainfall with an apparent cycle of 12-14 years** and with the 4 zones behaving similarly (Fig. 35).

When the monsoon is very strong, all 4 zones have heavy rainfall like in the years 1982, 1994 & 2008. When the monsoon is weaker, all 4 zones have lower rainfall like in the years 1986 & 2002.

As shown on Fig. 36, there are years of heavy rainfalls such as 1997 where annual rainfall goes up to 7000 mm/year (275 inch/year) in the West and 2500 mm/year (100 inch/year) in the East, but there are also years of low rainfall such as 2002 where annual rainfall goes down to 3500 mm/year (120 inch/year) in the West and less than 1000 mm/year (40 inch/year) in the East.

From this apparent cycle, it can be predicted that the rainfall is likely to be lower in the coming years to a very low level in 2014 to 2016.

The data shows that the day of the beginning of the rainy season is fluctuating a lot from one year to the next and is situated at around day 145 (i.e. May 25th). The analysis shows that on average the start of the rainy season has changed very little since 1975 at the rate of 0.05 day per year, and hence the rainy season starts on average only by one day late after 20 years (Fig. 37a).

Figure 35: Rainfall distribution in the Kavery watershed for a year of heavy rainfall (1997) versus a year of low rainfall (2002).

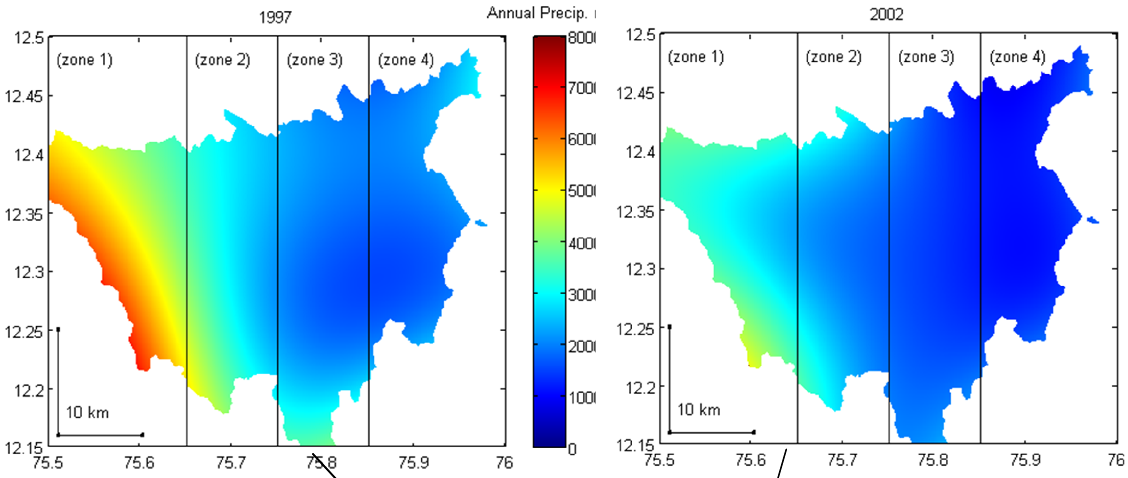
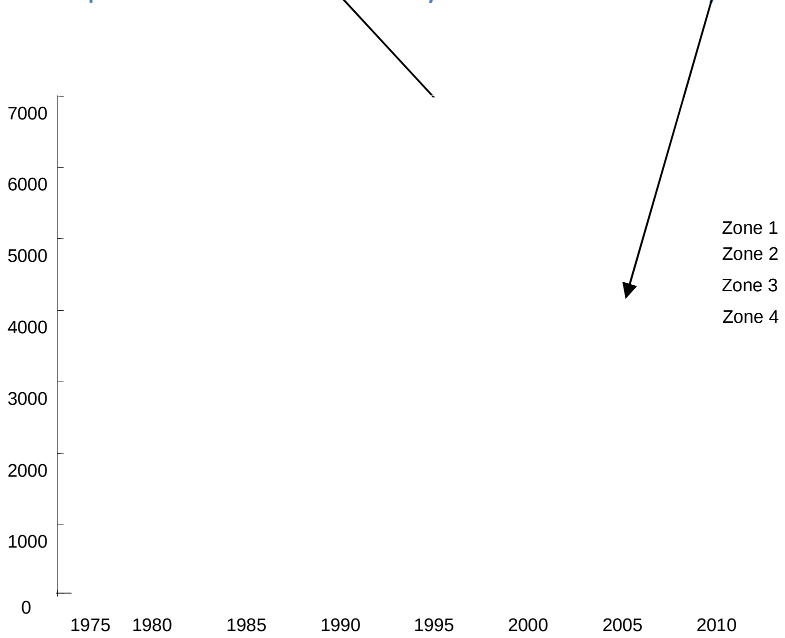


Figure 36: Annual rainfall pattern of the 4 zones of the Kavery watershed over the last 30 years.



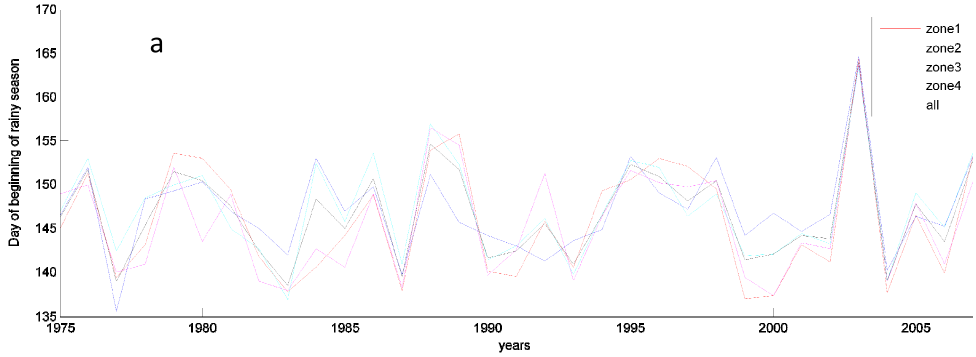


Figure 37: Fluctuations in the date of the beginning (a) and end (b) of the rainy season over the last 3 decades in the Kavery watershed

The data show that the last day of the rainy season is also fluctuating a lot from one year to the next and situated around day 315 (November 10th). More importantly, the analysis shows that the last day of rain is coming earlier year after year since 1975 at the rate of 0.35 day per year, and hence 10 days earlier after 30 years (Fig. 37b).

Figure 38: Fluctuation in the length of the rainy season over the last 3 decades in the Kavery watershed

As a consequence, the average length of the rainy season has been decreasing over the last 35 years (1975-2010) at the rate of 0.4 day per year, and hence **the rainy season has shortened on average by 14 days over the last 35 years** (Fig. 38)**.**

Conclusion

Thanks to the valuable collaboration of over 80 farmers that have registered rainfall data for decades in the Kavery watershed, the analysis done by CAFNET team in India indicates that:

- There is a strong fluctuation of annual rainfall with an apparent cycle of 12-14 years,
- From this apparent cycle, it can be predicted that the rainfall is likely to be lower in the coming years to very low level in 2014 to 2016,
- The length of the rainy season has decreased by 14 days over the last 35 years.

Carbon sequestration

Over the last 25 years, the landscape of the Kodagu district has strongly evolved with coffee plantations expanding toward the Western part of the district, reducing forest areas to fragments, similarly to the Eastern zone. Due to the stem borer (*Xylotrechus quadripes*), many farmers have converted Arabica to Robusta as it is more resistant, easier to manage and requiring less shade. Furthermore, native trees are being replaced by fast growing tree species, particularly the exotic species *Grevillea robusta,* due to tree rights and land tenure issues that prevent farmers to fell and freely market wood from native species, and willingness of farmers to diversify their revenues through production of wood and pepper.

This motivated a study by the CAFNET team on the impact of shade tree composition and coffee management (Arabica or Robusta) on carbon sequestration (above and belowground). To do so, the studies compared shade cover made predominantly of a mix of native tree species to shade cover mainly constituted by the exotic species, *Grevillea robusta,* in reference to forest along a West-East rainfall gradient in the Kavery watershed of the Kodagu district.

Three contrasted zones were selected in terms of rainfall regime along the West-East transect (Deciduous Eastern zone: ~1200 mm/year; Central zone: ~3000 mm/year; Evergreen Western zone: ~5000 mm/year) in the Kavery watershed.

A minimum of 5 sites comprising a forest reference and various coffee systems (Arabica or Robusta shaded by either predominantly native or exotic tree species) were studied in each zone with a total of 22 sites and 67 plots surveyed. To compare accurately the different systems in the highly variable ecological conditions of the Kodagu district, plots close to each other (<300m) were selected within a site to have similar rainfall regime, topographical and soil characteristics (notably soil texture) and under the same management for more than 10 years.

Table IV. Mean shade level (%), basal area (m^2/ha) and carbon sequestered (t/ha) in reference forest (Forest) coffee (Arabica or Robusta) agroforestry systems shaded predominantly with native tree species (Native) or exotic species (Exotic) in 3 ecological zones (EAST: ~1200 mm/year; CENTRAL: ~3000 mm/year; WEST: ~5000 mm/year) in the Kavery watershed of the Kodagu district.

	ZONE			Overall
System	EAST	MIDDLE	WEST	Watershed
Shade level (%)				
Forest	61	87	91	76
Arabica Native	69	-	-	69
Arabica Exotic	66	-	-	66
Robusta Native	53	47	32	43
Robusta Exotic	55	41	36	45
Basal Area (m^2/ha)				
Forest	37	42	22	34
Arabica Native	32	-	-	32
Arabica Exotic	27	-	-	27
Robusta Native	28	28	26	27
Robusta Exotic	20	16	13	17
Carbon (t/ha)				
Forest	222	189	163	196
Arabica Native	206	-	-	206
Arabica Exotic	183	-	-	183
Robusta Native	192	172	179	182
Robusta Exotic	163	131	115	138

In each selected plot, aerial canopy biomass was assessed via the allometric relationship already developed. Aerial biomass of Robusta and Arabica plants were estimated from allometric relationships based on destructive samplings of 25 plants. Soil samples and litter were also collected to measure their carbon content.

An important aspect to notice was the fact that C sequestration decreased from East to West (hence from drier to wetter conditions) in reference forest and Robusta shaded with the exotic species (Table IV). Carbon sequestration of Robusta shaded by exotic species was much lower than reference forest and other coffee AFS.

The results showed that coffee AFS composed of Arabica shaded by either native or exotic tree species sequestered C at the same rate as reference forest (Table IV). To a lesser extent, this also appears to be the case for Robusta AFS shaded with native species.

The results also confirm that the conversion of Arabica to Robusta reduces shade level.

With values in the range of 140-220 t/ha, total carbon sequestered in the present coffee systems are well above the median C sequestration potential of other agroforestry systems estimated at 95 t/ha in the tropical AFS, but in the same order of magnitude with that of a Robusta AFS in West Africa and comparatively higher than Arabica AFS studied in Central America.

Table V. Mean carbon sequestered (t/ha) in the various components of reference forest (Forest) and coffee (Arabica or Robusta) agroforestry systems shaded predominantly with native tree species (Native) or exotic species (Exotic) in the Kavery watershed of the Kodagu district.

Carbon (t/ha)					
System	Tree	Coffee	Soil	Litter	Total
Forest	97	-	97	2,4	196
Arabica Native	88	4,8	112	1,6	206
Arabica Exotic	73	3,3	105	2,2	183
Robusta Native	78	13,0	90	1,8	182
Robusta Exotic	47	10,1	78	1,9	138

Table V shows that tree biomass and soil are the 2 major carbon pools as they represent over 90% of the total carbon whereas the contribution of coffee plants and litter is minimal.

Arabica AFS, particularly with native species, sequestered comparable amount of C as reference forest. A decline in C sequestered in Robusta AFS shaded with the exotic species *Grevillea robusta* is quite noticeable, especially in the wetter zones (Western and Central).

This study confirms the strong potential of coffee AFS shaded by native species to act as C sink. Consequently, incentives and policies should be put in place to reward farmers maintaining a high density and diversity of native tree species and to avoid a rapid conversion to coffee AFS predominantly shaded with exotic species and hence to preserve the largest range possible of ecosystem services, including carbon sequestration, provided by these coffee systems. This could be achieved by a combination of eco-friendly coffee labels and payment for environmental services by local and/or international schemes such as REDD (Reduction of Emissions from Deforestation and forest Degradation).

Coffee quality

India is the fifth largest world coffee producer with Robusta coffee representing more than 70% of its production and grown mainly at altitudes of 800-1000 m. This confers to Indian Robusta an international fame as high-altitude Robusta and a quality premium on the international market. Furthermore, Indian Robusta is mainly grown under the shade of multi-strata systems, mostly in the Western Ghats, one the world hotspots of biodiversity. Although less dense than for Arabica, shade tree composition in Robusta systems is constituted by highly diverse native species, but the conservation of such biodiversity-rich coffee systems is a challenge with the recent introduction of *Grevillea robusta*, a fast-growing exotic timber species.

At the onset of the CAFNET project, no information was available regarding the effect of shade level and on the specific effect of individual shade tree species on Robusta and Arabica quality in India.

To fill this important gap, two studies were conducted by the CAFNET project. A large study was undertaken for Robusta in 102 Robusta coffee agroforestry systems along an East-West transect (Deciduous Eastern zone: ~1200-1800 mm/year; Central zone: ~1800-3000 mm/year; Evergreen Western zone: ~3000-5000 mm/year) in the Kavery watershed of the Kodagu district. A second one was conducted in 10 farms on the specific effect of single tree species on both Arabica and Robusta quality under the canopy of 5 tree species, 4 native species (*Artocarpus heterophyllus*, *Dalbergia latifolia*, *Acrocarpus fraxinifolius, Ficus racemosa* or *Lagerstroemia microcarpa*) and the exotic species (*Grevillea robusta*).

Cup testing was undertaken at the Coffee Lab in Bangalore with cup quality scored on a scale from 0 to 10.

For Robusta (Table VI), increasing the % of *Grevillea robusta* in the shade composition did not have any significant effect on the out-turn (% of green beans / fresh berries) or the % of beans of large sizes mainly due to the fact that results are highly variable. On the other hand, an increasing % of the exotic species resulted in a decrease in cup quality (Table VI) as well as aroma and body (data not shown).

For Arabica, shade level (50-75% and >75%) had no effect on quality (data not shown). Increasing the % of *Grevillea robusta* did not affect out-turn or cup quality, but decreased the proportion of large beans (Table VII).

Table VI. Effects of % *Grevillea robusta* in the canopy composition on out-turn (% green beans / fresh berries), % of large beans (%AA) and cup quality (scale of 0-10) of Robusta in the Eastern (dry), Central (wet) and Western (very wet) zones of the Kodagu district.

	Out-turn (%)			% AA			Cup quality		
% of *G. robusta*	East	Central	West	East	Central	West	East	Central	West
<10%	21.5 a	21.3 a	21.6 a	27.1 a	31.1 a	25.4 a	5.58 a	5.57 a	5.54 a
10-30%	22.4 a	23.0 a	23.0 a	27.6 a	31.8 a	30.7 a	5.73 a	5.56 a	5.42 a
30-50%	22.0 a	22.9 a	20.0 a	37.9 a	30.2 a	30.3 a	5.29 b	5.60 a	5.25 b
>50%	22.9 a	20.2 a	20.0 a	33.0 a	39.4 a	35.3 a	5.28 b	5.33 b	5.25 b
Zone Mean	22.0 A	21.8 A	21.1 A	30.7 A	33.2 A	30.4 A	5.49 A	5.51 A	5.43 A

** Within a zone, small letters indicate statistical significance (P=0.05) according to the Newman and Keuls test.*

*** Between zones, capital letters indicate statistical significance (P=0.05) according to the Newman and Keuls test.*

The results showed for Robusta (Table VIII) a tendency of the out-turn (% of green beans / fresh berries) to increase from East to West (hence from dry to very wet conditions) whereas bean size (% of AA) tended to decrease from East to West.

Table VII: Effects of % *Grevillea robusta* in the canopy composition on out-turn (% of green beans/ fresh berries), % of large beans (%AA) and cup quality (scale of 0-10) of Arabica in the Eastern zone of the Kodagu district.

% Grevillea	Out-turn (%)	AA (%)	Cup quality (over 10)
0-10	15.3 a	46 a	5.48 a
10-20	16.0 a	41 a	5.64 a
20-50	15.6 a	41 a	5.65 a
>50	15.2 a	34 b*	5.54 a

**Small letters within a column indicate statistical significance (P=0.05) according to the Newman and Keuls test*

Regarding the specific effect of a particular tree species, shade by the exotic species *Grevillea robusta* resulted in a higher proportion of beans with large sizes in the East in comparison to the native species, but to a lower one (along with *Artocarpus*) in the West (Table VIII). These results also showed that shade of the exotic species leaded to a lower cup quality in the West. This indicates that *Grevillea robusta* is not a suitable shade tree for Robusta coffee quality in wet conditions.

Table VIII. Effects of tree species on out-turn (ratio of green beans / fresh berries). % of large beans (AA) and cup quality (scale of 0-10) of Robusta coffee in the Eastern (dry). Central (wet) and Western (very wet) zones of the Kodagu district.

	Out-turn (%)			% AA			Cup quality		
Canopy species	East	Central	West	East	Central	West	East	Central	West
Artocarpus	20.1 a	20.8 a	21.4 a	38.1 b*	31.2 a	19.0 b	5.68 a	5.78 a	5.75 a
Dalbergia	19.9 a	21.7 a	20.4 a	32.2 b	29.9 a	23.7 a	5.61 a	5.66 a	5.70 a
Lagerstroemia	20.1 a	20.6 a	21.6 a	36.2 b	31.5 a	24.7 a	5.60 a	5.74 a	5.74 a
Grevillea	20.6 a	20.9 a	21.8 a	47.5 a	27.0 a	17.7 b	5.65 a	5.79 a	5.54 b
Zone Mean	20.2 B	21.0 A	21.3 A	38.6 A**	29.9 B	21.2 C	5.64 A	5.74 A	5.68 A

** Within a zone, small letters indicate statistical significance (P=0.05) according to the Newman and Keuls test.*

*** Between zones. capital letters indicate statistical significance (P=0.05) according to the Newman and Keuls test.*

For Arabica in the Eastern zone, out-turn and proportion of large beans were lower under the shade of the native species *Dalbergia* than under any other species, including the exotic one (Data not shown). On the other hand, coffee quality was lower under shade of *Acrocarpus* and *Artocarpus*, but not under *Grevillea robusta*.

From these studies, it can be concluded that:

- the exotic species, *Grevillea robusta*, is not a particularly suitable shade tree for Robusta coffee quality especially in wet conditions (western zone) as proportion of large beans and cup quality significantly decrease with increasing % of this species in the shade composition.
- In the dry conditions of the Eastern zone, Grevillea robusta does not affect greatly Arabica quality except for bean size when the proportion of this exotic species is very high (>50%).
- Although *Grevillea robusta* does not strongly affect coffee quality, the CAFNET team advocates for the maintenance of a high diversity of native tree species in the agroforestry systems of Kodagu and that % of *Grevillea robusta* does not exceed 30%.

Quantification of fuel wood in coffee based agro forestry systems

Fuel wood is the most important source of energy for domestic use in many third world countries. A major part of fuel wood has been found to originate from trees on non-forest land, which in many cases will mean from some kind of agroforestry system. Agroforestry systems are therefore beyond doubt a very important fuel wood supplier. Coffee based agroforestry is extensively advocated as a sustainable and productive form of land use. The present study was carried out by Miss. Swetha, JRF, CAFNET as a part of her Master degree program in Forestry at COF, Ponnampet on "Quantification of fuel wood in coffee based agroforestry systems" with the following:

- To quantify the fuelwood productivity in coffee based agroforestry.
- To study the consumption pattern of fuelwood supplied by coffee based agroforestry.
- To quantifiy the proportion of energy requirement met by coffee based agroforestry.

Figure 39: Fuelwood coming from the coffee estates.

The study was carried out in the coffee based agroforestry of the Kavery watershed area of Kodagu district. Stratified Random Sampling was adopted. The study area was divided into three zones based on rainfall and vegetation i.e. (a) Eastern zone - Annual rainfall of 40- 70 inches with deciduous vegetation (b) Central zone-Annual rainfall of 70-110 inches with semi evergreen vegetation (c) Western zone-Annual rainfall ranging between 110-200 inches with evergreen vegetation. Within each zone two cluster of major consumption centres were identified. Within each cluster in addition to the major consumption centre, one village located between 5-10 KM from the consumption centre was identified totalling to 12 study sites.

A field survey was carried out during June 2010 to July 2011. Nine farmers based on their size of land holding, three from each category i.e. (i) Small (< 5 acres) (ii) Medium (5–25 acres) and (iii) Large (>25 acres) were selected from each of the 12 study sites and hence totally 108 land owning (36 large, 36 medium, 36 small) and 36 landless respondents were selected making up a total of 144 respondents. The quantity of fuelwood consumed by farmers was measured using a stack measurement as in weight survey methods. For quantification of fuelwood used by labourer's observations were recorded on the number of head loads used per week.

In order to quantify the use of fuelwood on-farm 36 households (12small,12 medium and 12large) were randomly chosen. The first step involved in quantification of the fuelwood obtained from coffee based agroforestry includes recording shade percentage, measuring tree girth, height and fuelwood obtained from preferred fuelwood species.

Table IX: Consumption of energy per 30 days among different season in the study area

	Monsoon	Winter	Summer
Fuelwood (kgs)	2274.12± 502.14	1517.42 ± 373.57	1074.91 ± 243.01
LPG (kgs)	11.87 ± 3.06	12.16 ± 1.87	14.93 ± 2.10
Electricity (unit)	161.12 ± 52.04	178.87 ± 53.91	202.78 ± 56.97
Kerosene (litres)	1.93 ± .30	1.72 ± .26	1.60 ± .23

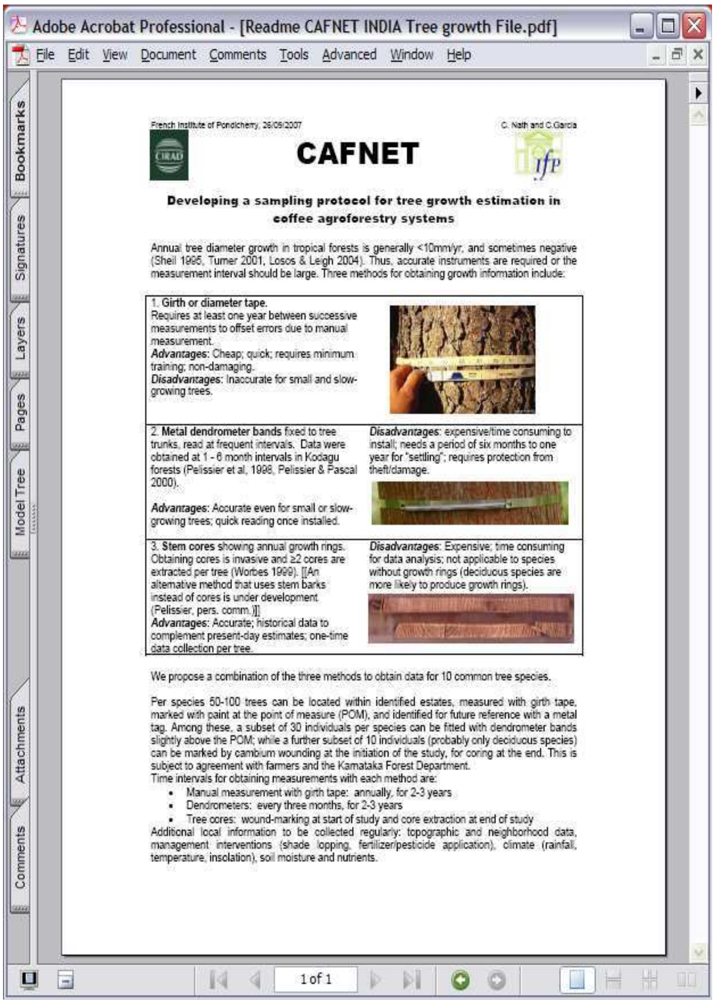
The majority of households (85%) depend on fuelwood for their domestic energy needs. Fuel wood consumption was highest in monsoon, followed by winter and summer. The consumption of fuelwood and kerosene peak in monsoon whereas electricity consumption increased in summer (Table IX).

Regarding consumption per farm size, Fuelwood consumption was highest among small farm size (2323 kg/household/30days) and least among the large farmers (823 kg/household/30days). The share of LPG (15.71 kg/household/30days), electricity (291.66 unit/household/30days) and kerosene (2.40 litres) was higher in larger farms.

There is a gap of information on the links between agroforestry land use and wood fuel supply. However our data shows that coffee based agroforestry systems are already a very important wood fuel supplier and have the potential to meet the wood fuel demands. The use of wood to meet the energy requirements in coffee based agroforestry systems is a traditional practice. Wood is likely to continue as the most important universal fuel for rural areas of developing countries and the demand will increase enormously in the coming decades. It is a renewable energy and its production can be sustained. It is the most accessible and cheapest source of energy for most of the rural people. Ensuring trees are a substantial part of the production landscape therefore reduces the pressure on existing forests and enables to balance conservation and development. A trend of intensification, as observed in other coffee production areas would reduce the availability of firewood and it would be the smaller farmers that would again bear most of the cost of this ecosystem change.

Activity 2.4 .Validation of agro forestry practices.

Tree growth rates



Adobe Acrobat Professional - [Readme CAFNET INDIA Tree growth File.pdf]

French Institute of Pondicherry, 26/09/2007

C. Nath and C.Garcia

CAFNET

Developing a sampling protocol for tree growth estimation in coffee agroforestry systems

Annual tree diameter growth in tropical forests is generally <10mm/yr, and sometimes negative (Sheil 1995, Turner 2001, Losos & Leigh 2004). Thus, accurate instruments are required or the measurement interval should be large. Three methods for obtaining growth information include:

1. **Girth or diameter tape.** Requires at least one year between successive measurements to offset errors due to manual measurement.
Advantages: Cheap; quick; requires minimum training; non-damaging.
Disadvantages: Inaccurate for small and slow-growing trees.

2. **Metal dendrometer bands** fixed to tree trunks, read at frequent intervals. Data were obtained at 1 - 6 month intervals in Kodagu forests (Pelissier et al, 1998, Pelissier & Pascal 2000).
Advantages: Accurate even for small or slow-growing trees; quick reading once installed.
Disadvantages: expensive/time consuming to install; needs a period of six months to one year for "settling"; requires protection from theft/damage.

3. **Stem cores** showing annual growth rings. Obtaining cores is invasive and ≥2 cores are extracted per tree (Worbes 1999). [[An alternative method that uses stem barks instead of cores is under development (Pelissier, pers. comm.)]]
Advantages: Accurate; historical data to complement present-day estimates; one-time data collection per tree.
Disadvantages: Expensive; time consuming for data analysis; not applicable to species without growth rings (deciduous species are more likely to produce growth rings).

We propose a combination of the three methods to obtain data for 10 common tree species.

Per species 50-100 trees can be located within identified estates, measured with girth tape, marked with paint at the point of measure (POM), and identified for future reference with a metal tag. Among these, a subset of 30 individuals per species can be fitted with dendrometer bands slightly above the POM; while a further subset of 10 individuals (probably only deciduous species) can be marked by cambium wounding at the initiation of the study, for coring at the end. This is subject to agreement with farmers and the Karnataka Forest Department.
Time intervals for obtaining measurements with each method are:

- Manual measurement with girth tape: annually, for 2-3 years
- Dendrometers: every three months, for 2-3 years
- Tree cores: wound-marking at start of study and core extraction at end of study

Additional local information to be collected regularly: topographic and neighborhood data, management interventions (shade lopping, fertilizer/pesticide application), climate (rainfall, temperature, insolation), soil moisture and nutrients.

Figure 40: Spreadsheet describing the Tree Growth Estimation protocol.

Our assessment of the canopy cover of the complex, multistoried coffee agroforestry systems of Kodagu district in southern India show they harbor more tree species than most other coffee plantation areas elsewhere in the world. The farmers recognize and appreciate the value of this biodiversity. In addition, timber acts as a supplementary source of income, increasing the economic resilience of the coffee estates. However, the current structure of the supply chain and the rules and regulations that constrain the management of the timber are driving the coffee growers to replace the original and diversified shade cover with *Grevillea robusta,* a fast growing exotic tree species.

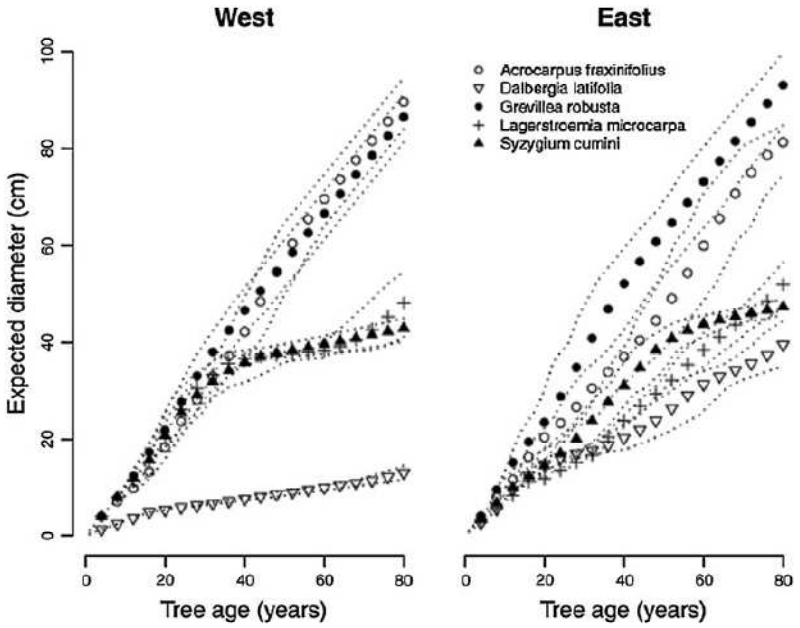
In order to identify and propose alternatives to the local stakeholders and the State Forest Department, CAFNET project compared the growth rates of four common native timber species, *Acrocarpus fraxinifolius, Syzygium cumini, Lagerstroemia microcarpa* and *Dalbergia latifolia* against that of *G. robusta.* The protocol was shared with CAFNET team outside India through a spreadsheet (Fig. 40). We equipped 332 trees distributed across 13 coffee estates with steel dendrometer bands to obtain reliable high resolution data on annual diameter increments between March 2008 and March 2010. The monitored trees were spread out across 13 coffee estates of Kodagu, with six estates located on the eastern side and seven on the western side of the district. These correspond to the two main bioclimatic zones of the district: the eastern side with moist or dry deciduous vegetation, and the western side with wet evergreen vegetation.

The annual diameter growth rates were calculated in order to compare the different species monitored. The average diameter increment of trees on the eastern side of the district was 0.92 cm/yr, while trees on the western side grew at 0.96 cm/yr. Species ranked by descending order of average diameter growth rate were as follows: *G. robusta* (1.32 cm/yr), *Acrocarpus fraxinifolius* (1.24 cm/yr), *Lagerstroemia microcarpa* (0.84 cm/yr), *Syzygium cumini* (0.76cm/yr), *Dalbergia latifolia* (0.50 cm/yr).

Three of the four native species had slightly higher growth rates on the wetter western side of the district than on the drier eastern side. In addition, in the western side *A. fraxinifolius* had faster growth than *G. robusta*. This was because large trees of *G. robusta* did not grow well in the wet zone. Pairwise comparisons between *G. robusta* and each of the native species showed that *G. robusta* growth rates were significantly faster than all native species except *A. fraxinifolius.*

Box 3: Projections of tree growth based on the measured annual growth rates (from Nath et al, 2011).

Fig. 3 Expected average age-size trajectories, with 95% confidence envelopes, obtained by computer simulation of growth rates for five tree species in coffee plantations of the eastern and western bioclimatic zones of Kodagu, Western Ghats of India



Thus, it can be concluded that the native species, *Acrocarpus fraxinifolius*, produces growth rates comparable to those of Silver oak. Stochastic projections of growth rates to obtain age-size trajectories showed that for most species the long term performance was influenced by bioclimatic zone. Local environment effects such as competition from coffee bushes or the direction the stand faces also played a role.

According to our study, farmers selecting *A. fraxinifolius* over *G. robusta* would increase their timber yield in the western side of the district. However, there is no denying that few species can match the growth rates of *G.robusta*, making it an obvious choice for farmers in the current situation.

This work was carried out by Dr. C.Nath (FIP). The results have been published in Agroforestry Systems (Nath et al. 2011) and the paper can be accessed here: **http://www.springerlink.com/content/hw10gp5518467536/**

Understanding the drivers behind canopy management

The identification of the farmers strategies in respect with the management of the tree cover in their estates was conducted through a participatory modeling approach ("Companion modeling", http://cormas.cirad.fr/ComMod/), in collaboration with the ANR-French National Research Agency Project Public Policies and Traditional Management of Trees and Forests (POPULAR) and CIRAD. Jeremy Vendé (AgroParisTech), Claude Garcia (CIRAD/FIP) and Christophe Lepage (CIRAD) designed a Role Playing Games (RPG) called KODAGAME to serve as a discussion platform between stakeholders and policy makers, to explore alternative scenarios and possible long term impacts at the landscape level.

In this model, instead of relying on probabilities, management decisions are taken directly by the stakeholders themselves, while the natural dynamics (growth of the trees, coffee yields, etc.) are handled by the model (equations, population models, etc.) with the assistance of a computer. The player (Coffee owner) needs to manage the crops (Coffee, Pepper, G. robusta and Jungle Wood) and production factors (Chemical inputs, irrigation infrastructures and labor allocation). In addition, they need to interact with other stakeholders: Markets, the Forest Department, the Timber Merchants and the other players (Fig. 41).

Figure 42 shows the management block and the various elements the players had to manage during the sessions. We conducted 5 sessions of the role playing game: three with farmers of the Kavery watershed and two with external stakeholders. The results validate our understanding of the drivers behind the decisions farmers take to manage the trees in their estate, and shed light on practices difficult to describe otherwise, such as the removal of natural regeneration by the farmers, keen to replace the native species with *Grevillea robusta.* The discussions generated by the game sessions enable us to identify that many of the farmers are conservative in their management approaches, and that the transitions happen essentially when the estate is handed over to another owner (inheritance or sale).

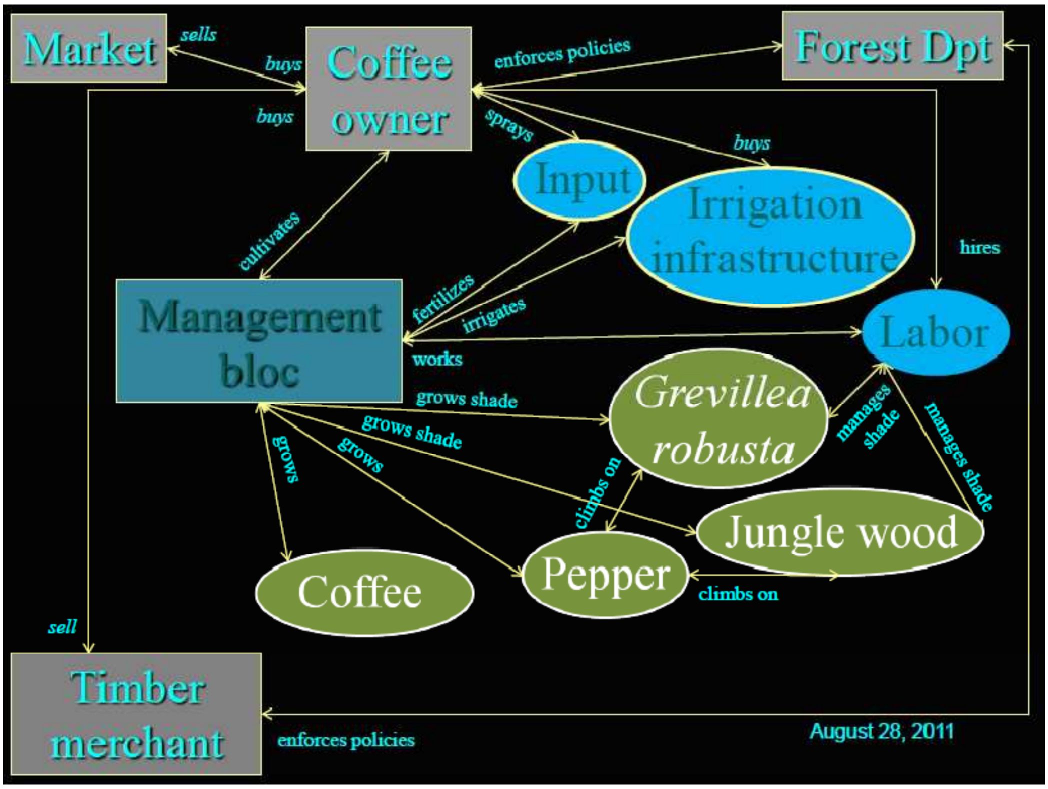


Figure 41: Theoretical model used for the creating of the Role Playing Game KODAGAME.

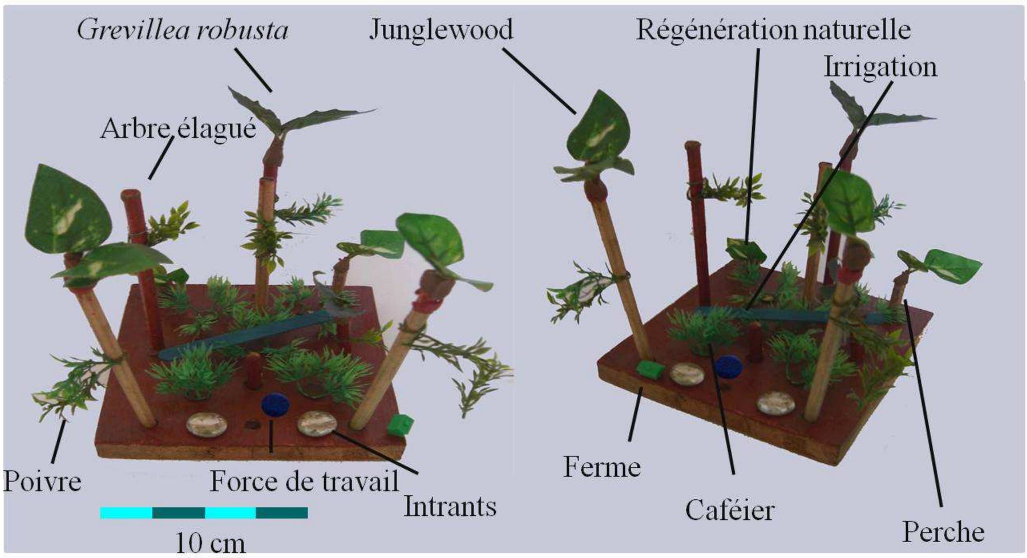


Figure 42: Components of the Role Playing Game KODAGAME.

This work was conducted between May and December 2009. A scientific paper is being prepared from the report (Vendé 2010).

Best Management Practices

Figure 43: Discussing « Best Management Practices », Chettaly, 16/09/09

An important meeting on formulation of "Best Management Practices" based on farmers knowledge was held at CRSS, Chettally on 16.09.09. The meeting was attended by all the regional partners and members of steering committee. It was decided that a guidance document in this regard comprising information on farmers' knowledge supported by scientific information would be drafted on twelve issues related to sustainable coffee production. Regional partners met on 29th and 30th May 2010 at College of Forestry, Ponnampet to review the issues related to progress of this guidance document. The template for the same was approved and it was resolved to make available the draft document for validation by farmers before publishing.

Activity 3.1. Valuation of environmental services

In India, following economic and biodiversity surveys undertaken in 115 reference farms (see activity 3.2. below), an economic valuation of carbon sequestration was undertaken in 2009-2010, particularly to evaluate the forgone revenues of maintaining or increasing the tree cover in coffee plantations to enhance carbon sequestration. The results showed that for Robusta farms an increase of 10 tons of carbon per Ha in coffee AFS leaded to a loss revenue of 8000 INR (120 €) per Ha per year. In some coffee farms, this loss could be partially compensated by the introduction of the exotic tree species, Grevillea Robusta, which is under no legal restrictions regarding commercialization and likely to result in higher pepper returns.

However, this trend is opposite to what CAFNET wants to propose, i.e. maintaining or enhancing the native tree diversity. Adding to these opportunity costs, the transaction costs (monitoring, institutions, financial costs, etc...) of a ton of carbon is likely to be in the range of 25 to 40 € annually which is far above its current price on the European trading scheme system, averaging 20 € in the past but currently very low (around 10 €). Furthermore, there is currently no institution (cooperatives, NGO or governmental institutions) in the region capable of implementing a program such as REDD (Reduction of Emissions from Deforestation and forest Degradation).

Therefore, carbon payment will have to be bundled with other direct or indirect payment (eco-certification) for other environmental services (water, biodiversity, scenic beauty) to become an effective strategy to conserve the native tree species-rich coffee agroforests of this region.

No other study on payment for environmental services was performed in India in the absence of a pilot scheme in place in the target region or state during the CAFNET project. Likewise, no cost-benefit analyses of eco-certification schemes could be performed in India (as compared to other sub-continents) as only a few large industrial coffee plantations were eco-certified during the time of the project and access to economic data was not permitted to the CAFNET team.

Activity 3.2: Value Chains and economic constraints

General Economic survey

In India, an economic survey, initiated in May 2008, was completed during the 2nd period (late 2009) on a total of 115 farms of 38 villages spread across the Kavery watershed. This survey has given us valuable information on:

- the cost and benefit associated with coffee cultivation across different farm sizes
- the cost of post harvest practices across different farms sizes,
- the economic importance of intercrops (pepper, cardamom, arecanut) and tree products (timber & fuelwood) in Robusta AFS.

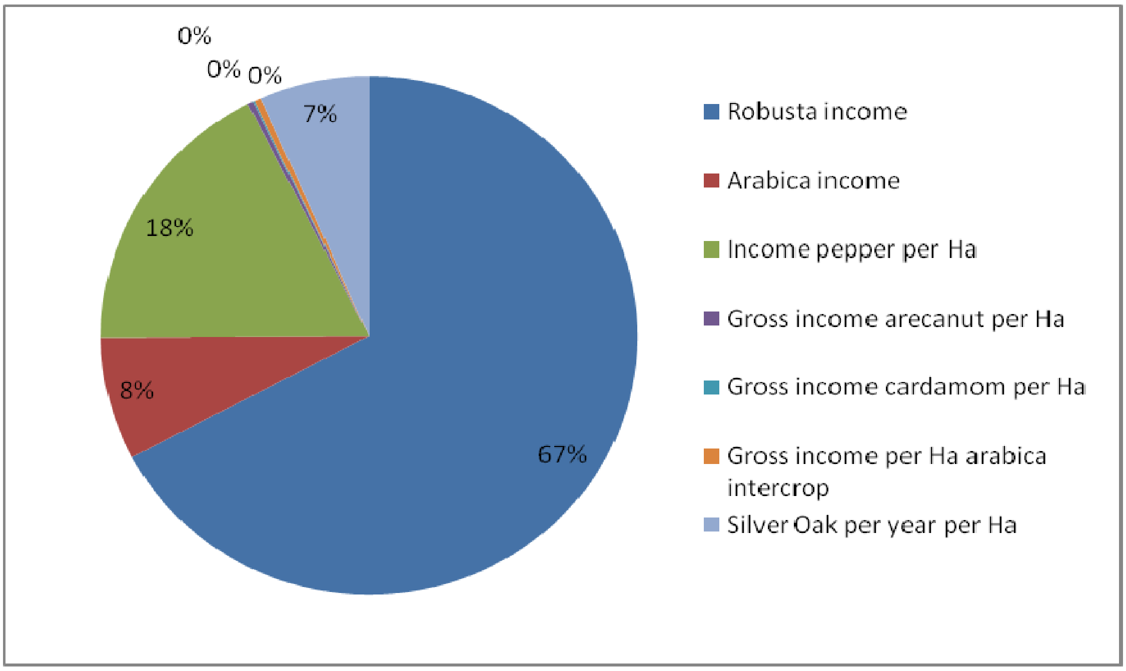


Figure 44: Distribution of income sources of coffee farms (Source: Chethana, 2008).

Results indicated that cost of production was higher in medium farms (10-50 acres) than small (<10 acres) or large farms (> 50 acres). The net income derived from intercrops (pepper, timber, fuelwood and cardamom) accounts for a large part (up to 40%) of farmers' revenues (Fig. 44). Results on this economic analysis of production systems in coffee were provided in September 2010 to individual farmers that participated in this study and in a workshop for a more general audience.

A graduate student of UASB Miss Chethana participated to this study and defended her M.Sc thesis on “Economic analysis of coffee production system for exploring the Socio-economic feasibility of geographical indications for Kodagu Coffee”. . Results at the watershed level were presented at the 2nd World Agroforestry Congress, Nairobi (August 2009) and a paper has been published (Chethana et al. 2010).

Robusta coffee in India is grown under shade, which pulls down coffee yields. The marginal loss in the productivity of coffee due to shade is not directly reimbursable through the shade benefits. Hence, the coffee planters need to be compensated through price premium for their products produced under rich biodiversity. The best way is to promote Geographical Indication for the Kodagu coffee for internalizing the ecosystem services. Normally, GIs are designed to defend valuable intellectual property and rights belonging to the community in a specific geographic boundary.

Most of the requirements for a label, like environment friendly practices (bio-diversity promotion) are being naturally met in the area. The link between environmental quality and reputation that would justify a GI is however tenuous, and can only be done through a chart of practices commonly discussed and agreed upon by the producers (Garcia et al. 2007). The coffee planters are highly educated and innovative. However, the concept of GI for the Kodagu coffee can’t be taken up by individual planters, as the owner of a GI needs to represent the common interest of the producers. Deciding who would be the leader, the owner of the GI is therefore crucial. The Coffee Board could play this role of leadership, as it is one of its prerogatives to promote the marketing of the Indian Coffee. It remains to be seen whether or not the producers would follow that leadership.

Although coffee from high elevation such as the Indian robusta has already a good reputation and fetches a better price that the average in the international market (Mercereau & Vignault 2008). Traders and roasters have used the region of origin of coffee also as an important attribute to decide on the quality of coffee beans.

The productivity of coffee has been found less under high shade and native tree cover (6 q/acre) than under low shade conditions (8.9 q/acre), without any significant difference in the input amount (Bo 4). A similar trend was observed for intercrops also, since exotic trees form good support for pepper because of their clear bole. Hence, it was the shade intensity that influenced the yield rather than tree density (number of trees per acre). The planters are advised to regulate only the shade and not to cut the trees. The statistics for the net income from coffee and intercrops depict the shade density on farm profitability. However, these planters need to be compensated for preserving bio-diversity through conservation of native trees. One of the modes of payment for the environmental services suggested is through a premium price for the

Kodagu coffee with Geographical Indication, as it would be expected that the benefits from the GI trickle down to producers.

Gains and Loss of Coffee Production under High and Low Shades

The details of gains and losses of coffee production under high and low shade conditions are presented in Box 4. The difference in productivity between high and low shades conditions was 2.9 q/acre . Of course, there was a difference in the amount invested for growing coffee under both the shade conditions. Actually, planters under high shade had invested lower amount compared to planters under low shade condition. Taking this also into account, the net gain was found to be around Rs 10.40/kg for the planters growing under low shade and exotic tree cover.

Box 4: Links between shade management and productivity (Chethana et al. 2010).

Table 4. A comparison of shade intensity, productivity and income from coffee

Particulars	High (> 70) intensity	Low (< 70) intensity	t-statistics
Area under coffee (acres)	6.5	21.1	2.7
Trees/acre	77	72	-0.5
Native trees (per cent)	93.5	79.8	-2.1
Exotic trees (per cent)	6.5	20.2	2.1
Ratio of exotics to natives	0.1	0.7	2.4
Coffee yield (q/acre)	6	8.9	2.2
Net income from coffee (Rs)	13950	23175	2.3
Total cost of cultivation of coffee (Rs)	13673	17739	1.3
Income from intercrops (Rs)	4759	7483	1.3
Net Income from coffee + intercrops (Rs)	18709	30658	2.9
Total cost /acre on coffee including intercrops (Rs/acre)	15696	19762	1.2

Note: > 70- values greater than mean+ Standard deviation
< 70- values less than mean+ Standard deviation

The net loss was estimated to be around Rs 15.50/kg for the planters growing under high shade and native trees cover. Hence, these planters should be compensated for the valuable ecosystem services provided by their mode of coffee plantations. The marginal loss in the productivity of coffee due to shade is not directly reimbursable through the shade benefits, the coffee planters need to be compensated through a price premium for their products produced under rich biodiversity, thus requiring the GI to ensure market access and price.

Eco certification initiative

During the year 2009-10 season the CAFNET project team held a series of meetings at different places in Kodagu district to spread awareness about the concept of eco certification. A total of seven meetings were organized in the entire Kodagu district during the period 25th May 2009 to 25th July 2009 in Napoklu, Cherambani, Virajpet, Valnoor and Madikeri. After many deliberations a group was formed in Cherambane and this 6 member group came forward for certification under the RFA and UTZ certification programmes.

The certification process with respect to Cherambane group of farmers continued with pre audit inspection of the farmers' estates through September 2009 with the help of representatives of Ecom Gill. The final audit inspection of the 6 member group from Cherambane was conducted by the IMO control on 23rd and 24th of October, 2009. During the month of April, 2010 the Rain Forest Alliance (RFA) issued a certificate to the farmers group through Ecom Gill. The group sold around 125 tonnes of Robusta cherry variety as certified coffee through Ecom Gill trading company at a premium ranging between Rs 1.5/- to Rs 4/- per kg.

Further to spread the message among the planters of other villages and regions, discussions were held with progressive farmers, planters associations, self help groups etc. During the period the farmers welfare association of Somwarpet taluk evinced interest in the concept. Subsequently a meeting was organized in Somwarpet on 23.04.2010.

Figure 45: Discussing Group Certification, Somwarpet 23/04/2010.

In addition a workshop cum training program on Eco certification was organized at College of Forestry, Ponnampet on 27.04.2010. About 25 farmers of the district took part in the workshop. Dr. C.G.Kushalappa, Regional coordinator gave an overview of the CAFNET project. Dr. Raghuramulu, Joint Director, Coffee board delivered a talk on the certification scenario in India. Dr. Philippe Vaast, general coordinator, gave an outlook on the international eco certification. Further the participants were enlightened on experiences of certification process of Cherambane group.

Encouraged by the success of the Cherambane initiative the CAFNET team further conducted a series of farmer meetings so as to replicate this success in other regions**.** The details of the meetings are presented in Table X below.

During these meetings the members of certified group from Cherambane were also invited to share their experiences with the participating farmers. Following these meetings, five groups of farmers in the following villages have shown interest to participate in the certification programme.

1. Srigandha Farmers Club, Somwarpet – 25 members
2. Valnoor Farmers Group, Valnoor – 10 members
3. Siddapur Planters Group, Siddapur – 7 members
4. Kirundadu Planters Club, Kirundadu – 9 members
5. Begoor Farmers Group, Begoor – 10 members

Table X: Details of the Farmer meetings held on Eco certification

Date	Place	Number of farmers present
01.07.2010	Ponnampet	18
08.07.2010	Kanoor	16
11.07.2010	Hudikeri	15
16.08.2010	Begoor	17
17.08.2010	Hachinad	16
23.08.2010	Sulugod	15
25.08.2010	Kirundadu	10
31.08.2010	Ponnampet	16
01.09.2010	Siddapur	15
13.09.2010	Hoddur	25
17.09.2010	Betoli	13
24.09.2010	Gonikoppa	8
28.09.2010	V.Badaga	16
22.10.2010	Madikeri	18

The CAFNET team along with representatives of Ecom Gill visited the estates of group members 2-3 rounds towards pre audit inspection. During first visit the team evaluated the estates against the certification norms and after identifying the lacuna suggestions were made to improve upon them. During the second visit the team ensured that the farms adhered to the certification guidelines through necessary improvements. The third round of visits were conducted just before the final audit to check whether the book keeping is up-to-date and whether the farmer has gone through all other arrangements. The details of the inspection visit are furnished in Table XI below.

Figure 46: Discussing Group Certification, Betoli 17/09/2010.

Table XI: Details of pre audit inspection visits

Date	Inspection Team	Place visited	Number of Estates/farmers visited
04.10.2010	CAFNET & Ecom	Kirundadu	3
07.10.2010	CAFNET & Ecom	Valnoor	3
11.10.2010	CAFNET	Guyya	2
12.10.2010	CAFNET	Somwarpet,kusbur	8
15.10.2010	CAFNET & Ecom	Hoddur	5
19.10.2010	CAFNET	Kirundadu,Parane	3
21.10.2010	CAFNET & Ecom	Cherambane	4
26.10.2010	CAFNET	Siddapur,Arecad	4
03.11.2010	CAFNET & Ecom	Begoor	3
05.11.2010	CAFNET	Somwarpet	9
08.11.2010	CAFNET & Ecom	Valnoor, Thyagathur	4
11.11.2010	CAFNET	Hoddur	6
12.11.2010	CAFNET	Begoor	4
18.11.2010	CAFNET & Ecom	Betoli	3

Date	Inspection Team	Place visited	Number of Estates/farmers visited
24.11.2010	CAFNET	Guyya	3
10.12.2010	CAFNET & Ecom	Valnoor	5
13.12.2010	CAFNET & Ecom	Kirundadu	6
17.12.2010	CAFNET & Ecom	Begoor	7
08.03.2011	CAFNET & Ecom	Siddapur, Arecad	6
14.03.2011	CAFNET & Ecom	Kirundadu	8
17.03.2011	CAFNET & Ecom	Begoor	9
24.03.2011	CAFNET & Ecom	Betoli	3
25.03.2011	CAFNET & Ecom	Valnoor	9

After the completion of the pre audit inspections by CAFNET team and Ecom Gill teams and once the farmers were ready with all necessary arrangements, the final audit inspection was conducted by the external auditors namely M/s. IMO Control Pvt.Ltd., Bangalore during the following days:

Table XII: Details of pre audit inspection visits

Date	Group	No.of estates visited
28.12. 10	Cherambane farmers group	4
O3.01.11	Srigandha farmers club	2
04.01.11	Srigandha farmers club	3
12.04.11	Siddapur planters group	4
13.04.11	Kirundadu planters club	3
13.04.11	Valnoor planters group	3
14.04.11	Begoor farmers group	4

Date	Group	No.of estates visited
14.04.11	Valnoor farmers group	3

During the audit the auditors inspected the estates, labour quarters, godowns, drying yards and the maintenance of records. Following the inspection the auditing agency forwarded the report to the certifying body and based on it the entire farmer groups were conferred with certifications.

Figure 47: Audits in CAFNET farms.

After the completion of the coffee picking the farmers started approaching Ecom Gill for selling their eco certified coffee. During the current season the farmers were offered a certification premium of Rs.1/kg of cherry coffee in addition to the quality premium as per the out turn. The detailed profile of the certified coffee growers along with the volume of coffee traded with Ecom is enclosed in Annex 7.

Figure 48: Honoring the certified farmers. CAFNET Mela, Ponampet, 15/04/2011.

The farmers who participated in the certification programme were felicitated on behalf of CAFNET during the CAFNET Mela held at college of Forestry , Ponnampet on 14th & 15th April,2011. During the event the certified farmers shared their experiences and also gave clarifications to the apprehensions raised by the enthusiastic coffee growers about the certification initiative.

Future prospectus of certification initiative:

During the past two coffee seasons the CAFNET team along with coffee exporters has helped the growers to take up eco certification initiative. The growers have experienced betterment of their estate management through adoption of sustainable coffee cultivation practices. Further the growers were also compensated for their extra efforts through realisation of better margins for their certified produce. During the last one year the CAFNET team has participated in many events related to coffee industry and shared its experiences on the eco certification initiative. All these initiatives have lead to many enthusiastic coffee growers coming forward to undertake certification of their estates. Now the leading exporters like Ecom Gill, NED commodities have envisioned spreading the concept all across the coffee growing region to enable eco friendly and sustainable cultivation of coffee. Coffee Board of India also introduced an incentive scheme during 2010 for extending financial support towards eco-certification up to 75% of certification costs during first two years.

Activity 3.3: Legal constraints

One of the key issues of the coffee production system in Kodagu is related to ownership of land and trees on the farm. The district has 32 different land tenure systems and related ownership of trees which we grouped into full, partial or no rights over ownership and sale of native trees. In contrast exotic trees planted by the farmers can be harvested and sold without any restriction. Under such a situation earlier studies undertaken have indicated that density and diversity of shade is being alerted by farmers by replacing native trees with exotic trees mainly Silver Oak(Grevellia robusta) to increase their coffee productivity and income (Garcia et al. 2010). Hence efforts were undertaken by the project team to assess impact of land tenure and tree management on sustainable coffee production.

In association with the POPULAR project of FIP, a role playing model was introduced to selected farmers, steering committee members and team members so as to get inputs on issues related to tree management under different land tenure and ownership situations. This has been presented as part of activity 2.4. Seeing the results of such an approach, as second phase was conducted, this time fully under CAFNET project. Having obtained a fully functional model, validated by the stakeholders themselves, our objective was now to run a series of scenarios to understand the legal constraints that the farmers take into account when managing the trees in their estates. Further, it was decided to test the model involving larger number of farmers to understand the situation better and to draft policy briefs based on the results of these workshops.

We tested two scenarios regarding tree management. The business as usual scenario extrapolates the trends identified in the biodiversity database. The second one is the incentive scenario, where the protection of selected native species is reduced, enabling their felling and marketing. Farmers that demand the rights over the trees in their estate affirm that if they have ownership of this resource, they will manage it and protect it. The Forest Department thinks otherwise and expects to see a large scale conversion of native trees to *G.robusta* should the legal barriers to cutting trees be lifted. To explore these two antagonistic views of the future, we used the role playing game as a tool for prospective analysis.

We organized a total of 9 workshops, distributed all across the watershed. Each workshop lasted one full day, and had 5 to 8 farmers trying out the two scenarios. In total, 57 farmers created with us images of possible futures for the landscape of Kodagu.

Figure 49a: Coffee planters during a workshop on Timber regulation. Companion Modelling takes the form a one day workshop during which the participants engage in a game to represent their management of a coffee estate. The results are then discussed between the participants during a series of discussions led by a facilitator. Photo: V. Rao.

The results suggest that farmers with tree rights will first harvest native species at a large scale, and then replant Silver Oak on the basis of its fast growth rate (Fig. 49). This will have a positive impact on the livelihood of the farmers, as they can tap into a previously inaccessible resource (timber from jungle wood), but will reduce the diversity of the coffee production system. As trees in the estate also play a role of safety net in case of economic hardship (the timber can be sold when in need), this trend also increases the vulnerability of the farmers as the trees in the estates become increasingly younger and smaller. One last consequence is that we expect less carbon to be stored in the estates in this case.

We expected to see farmers replanting native species after this initial phase, but apparently, the differential growth rates between the native species and the silver oak proves to big an incentive, and farmers, after having cut most of their native trees, focus on replanting silver oak.

As a final observation, the business as usual scenario is not without problems. Even without modeling natural tree mortality, the existence of informal channels to generate revenue from the timber of the native species and the possibility to use their timber for bona fide use mean that slowly but surely the proportion of silver increases in the landscape.

These results suggest that simply giving access to the resource to the farmers will have negative consequences for the environment. As this measure will favor the farmers, it is a very distinct political option. However, in order to minimize the negative outcomes such a measure would have, alternatives, or accompanying packages must be proposed, such as ensuring that native species seedlings are available in the nurseries, and encouraging the retention of native species through incentive based mechanisms (Payment for Ecosystem Services, or fiscal measures). We hope to contribute to the ongoing debate on this policy issue with our scientific results during the months to come.

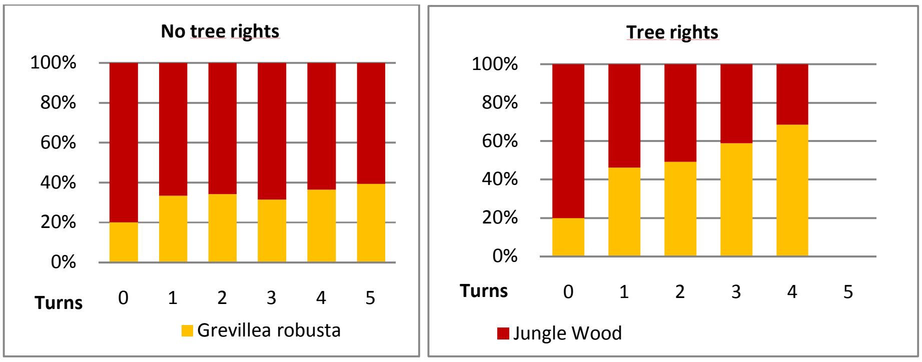


Fig. 49b: Evolution of the proportion of Silver Oak in the coffee estates under different scenarios. The results of the individual decisions of the farmers attending the Companion Modelling workshops allow us to suggest trends and dynamics under different scenarios. Here we present the results of one such workshop, held in Ponampet in November 2010. When the planters do not have the rights (as is currently the case in real life), the proportion of Silver Oak in the coffee estates the players are managing reaches a stable proportion (left). When the same players are presented with a situation where they can freely harvest jungle wood, the proportion of Silver Oak keeps increasing, as farmers strive to replace the slow growing species with the fast growing Silver Oak, to maximize their income (right). Such results suggest specific packages need to be devised if the rights are to be given to the farmers, in order to avoid the negative environmental impacts.

Activity 4.1 Refining of GIS tools for up-scaling

Right from the planning to the implementation CAFNET project remote sensing and GIS have been used extensively at various stages. The use of GIS for selection of watershed has been explained in Activity 1.1. For the upscale of various studies it was felt that the land use map initially update at a coarse scale was inadequate. As a result a fine scale mapping of a more accurate and detailed mapping was undertaken. The figure below distinguished the difference between the coarse scale mapping and fine scale mapping. The maps produced at the beginning of the project to monitor the land use changes between 1977, 1997 and 2007 were not able to discriminate between different types of coffee agroforestry systems. A new analysis done on the 2007 image has classified the area formerly under coffee into closed canopy coffee and open canopy coffee.

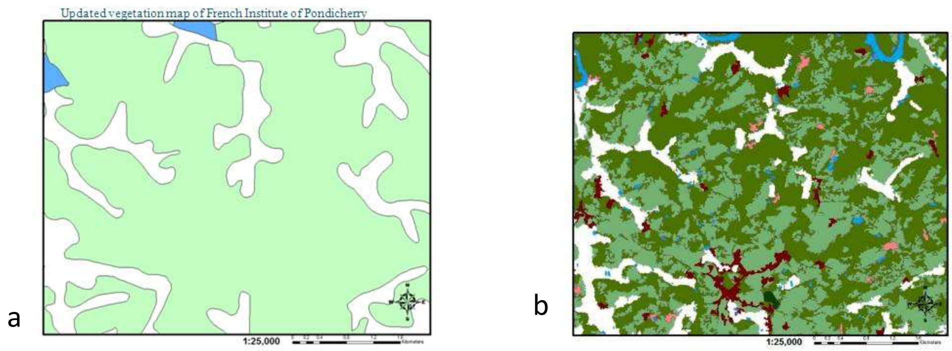


Figure 50: Refining the land use classification. An inset of the 2007 map (a) and the new revised classification (b) discriminating open and closed canopy coffee production systems.

Classification of Kavery watershed using IRS P6 LISS 4MX image:

The classification was undertaken using IRS P6 LISS 4 MX images from the Indian remote sensing satellite acquired by the NRSA, Hydrabad, India. The LISS-IV camera is a multispectral high resolution camera with a spatial resolution of 5.8m at nadir. Data are collected in three spectral bands:

1. 0.52 to 0.59 microns (Green (Band 2))
2. 0.62 to 0.68 microns (Red (Band 3))
3. 0.76 to 0.86 microns (NIR (Band 4))

A total of nine satellite image were acquires spread over an area of 1000 sq km of Kavery watershed for the mapping purpose. The details of the satellite images used are given below.

Table XI: Details of satellite images acquired to refine the classification of the Kavery watershed.

Image ID	Orbit	Scene	Shift	Date of pass
1	12078	147	20	13-02-2006
2	16639	121	50	31-12-2006
3	21072	122	10	08-11-2007
4	21072	123	10	08-11-2007
5	21143	122	50	13-11-2007
6	21143	123	40	13-11-2007
7	22777	089	30	07-03-2008
8	22777	090	20	07-03-2008
9	23459	122	10	24-04-2008

For the classification of land use a combination of software base and manual classification method was used. The satellite images were georeferenced using ground control points collected in the field. The satellite images were processed using ERDAS Imagine and feature analyst software. The output was manual cleaned to increase the accuracy of classification. The following land use classes and identification criteria was used for this purpose.

- Teak plantation:

These are areas in the eastern part of the watershed. Clearly demarcated with regular shapes on the FCC (False colour composite) of the Satellite images. These areas have high tree density and crown cover. This has been classified manually. Minimum mapping unit is 5000 sq m (0.5 ha).

- Closed Coffee:

These areas are areas with high tree cover (canopy) found in the coffee belt. The areas look dark red on the FCC and with shades of trees if trees with large canopy are found. The look more like the dense forests and the classification was manually cleaned after classification by software. Minimum mapping unit is 5000 sq m (0.5 ha).

- Open coffee:

These area are with minimum tree cover. Easily distinguished on the FCC by its bright red colour sometime with definite shape. Some of the paddy areas which have been converted to other landuse like areca fall in this category. Minimum mapping unit is 5000 sq m (0.5 ha).

- Built up area:

These include urban areas, large residential area, areas like scattered house in village colonies.

- Open areas

These are landuses that are not under any tree cover and cannot be put under any other land use. Usually found near rivers sides.

- Rivers, irrigation tanks and ponds.

The main river Kavery and Kakkab river as polygons, other large tanks and ponds more than 500 sq m are classified in this category.

- Grasslands

Easily distinguished as gray open areas on the FCC. Found on mountain tops on the western part of the watershed

- Forest dense

These areas look very similar to closed coffee area. These areas have been manually classified. Minimum mapping unit is 5000 sq m (0.5 ha).

- Rice Paddy

Areas seen as grey color on the FCC with regular shapes. Some small residential area and open areas next to paddy fields would have been classified in this category. However, it has been manually cleaned. Minimum mapping unit is 5000 sq m (0.5 ha).

- Irrigated agriculture.

These are agricultural areas mainly in the eastern part of the watershed fed by Harangi and Chikkihole reservoirs. They have regular shape. Classified manually after classification by software.

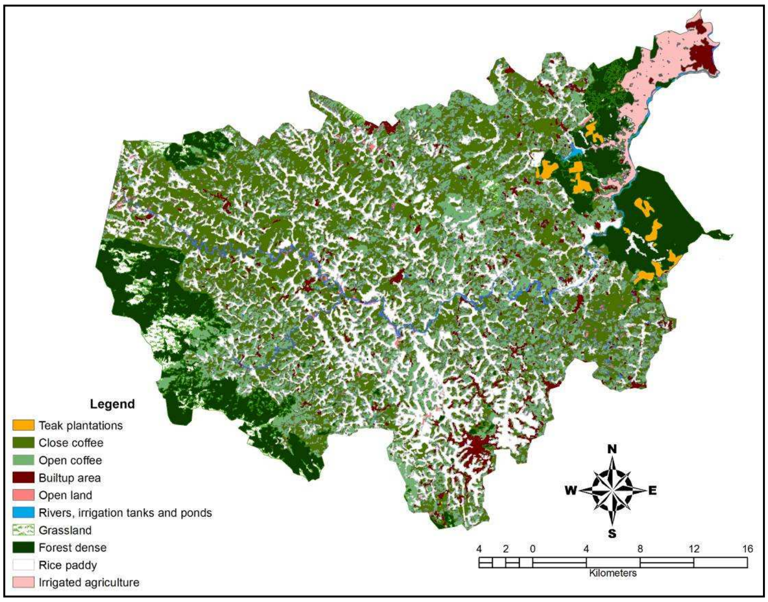


Figure 51: The classified map for the Kavery watershed area.

The classified image was tested for accuracy following standard assessment method. The assessment indicated an overall accuracy of 89 percent. The two classes of closed and open coffee indicated a producer's accuracy of 76 percent and user's accuracy of 84 and 65 percent respectively. The error matrix of for the classification is presented below.

Table XII: Error matrix of the classification, indicating the accuracy of the revised typology.

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Class 1-Teak plantations	85	81	81	95.29%	100.00%
Class 2- Closed coffee	185	169	142	76.76%	84.02%
Class 3- Open coffee	119	134	91	76.47%	67.91%
Class 4- Builtup area	92	85	80	86.96%	94.12%
Class 5- Open area	81	82	75	92.59%	91.46%
Class 6- Rivers, irrigation tanks and ponds	82	81	81	98.78%	100.00%
Class 7- Grasslands	89	83	81	91.01%	97.59%
Class 8- Forest	106	110	95	89.62%	86.36%
Class 10- Rice paddy	107	119	101	94.39%	84.87%
Class 11- irrigated agriculture	82	85	82	100.00%	96.47%
Totals	1028	1028	907		

Activity 5.1. Capacity building

One of the important activities under the project was to build capacity among the different stakeholders of the coffee community in the study area on different aspects relating to sustainable coffee production, valorization of environmental services provided by shade agro-forestry systems and climbing the value chain through the process of certification of sustainable production systems. The stakeholders like individual farmers & farmer collectives, traders of coffee & other products from coffee based cropping systems, Members of Steering Committee, representatives of Government and Non Government Organizations who can play a role in policy decisions, research and extension fraternity working on coffee, and students were the target groups for the capacity building initiative under the project.

Training programmes, seminars & workshops, group meetings were conducted on specific issues. During the CAFNET Mela-2011 held on 14-15 April 2011, hands-on-training workshops were also organized on specific topics like certification, eco-tourism, coffee quality evaluation for the participants.

Efforts undertaken by the project team in capacity building are highlighted hereunder:

5.1.1. Capacity Building efforts

i) For Steering Committee Members: which constituted of members of key institutions (The Coffee Board of India), organizations (Kodagu Planters association, Karnataka Planters association, UPASI, Kodagu Women's Coffee Awareness Body and Agricultural Sciences Forum of Kodagu) and various stake holders of the industry like Planters, Traders and Self Help Groups which were integral part of project implementation had interacted with the project team on a continuous basis have been successful in acquiring, disseminating and implementing practices with regard to valuation of ecosystem services in terms of carbon water and biodiversity conservation and sustainable production through eco certification .


Figure 52: Interactions with Steering Committee members at Coffee Research Sub-Station, Chettalli

ii) For Coffee Board of India Personnel

Extension officers of the coffee Board and research staff from the Coffee Research Substation were actively involved in the project. Extension officers were appraised about the different ecosystem service valuation initiatives, eco certification and other issues related to sustainable coffee production. Research staff from the department of soil science, agronomy and quality assessment actively took part in undertaking field studies and analyzing the results of studies, some of which were being undertaken by the project team for the first time in the country.

iii) For the Field and Research Personnel of CAFNET Project

Around 12 faculty, 30 research scholars and field assistants from the College of Forestry and University of Agricultural Sciences, Bangalore were trained on different aspects of documentation of ecosystem services in terms of biodiversity inventory, hydrological and carbon studies, economic analysis of production systems, coffee quality assessment, documentation of traditional ecological knowledge and other issues related to sustainable coffee production.

Figure 53: Visit of CAFNET team to IFP (left) and Interaction with project team at CRSS Chettalli (right).

iv) For private sector stakeholders

Stake holders of private companies involved in production and marketing of coffee were provided with information and trained in different aspects of valuation of ecosystem services and value additions of coffee. Management and research teams of TATA coffee Pvt.Ltd., BBTC and BCK plantations three of the largest private plantation companies interacted with project team and were trained on different aspects like inventorying biodiversity, hydrological studies, carbon assessment on their plantations. Interactive sessions on eco certification for RA and UTZ and Environment Impact Assessments for certification were facilitated by the project team. Partnerships were also established with two leading coffee trading companies Ecom Gill India Pvt. Ltd and Ned Commodities India for assisting farmer groups to undertake eco certification.

Project team assisted these companies in training their teams on various issues related to ecosystem service valuation and training of farmers' collectives.

v) For the Self Help Groups of Farmers

One of the key outcomes of the project was formation of 8 farmer groups involving 80 farmers by the project team for production and marketing of sustainable coffee. Self help group members were educated on a continuous basis to take up Sustainable Agricultural Standards and eco certification. Members were trained on internal control, market, trade alliances, good practices and explore coffee market and get exposed to domestic as well as international market setup and pricing. This effort is continuing even now and through various forums with CAFNET team members as resource persons. We expect around 8 more groups to be added to the existing groups.

vi) For the farmers in general

Participatory research involving 38 large, 38 medium and 38 small farmers were undertaken and farmers were oriented on different aspects of sustainable coffee cultivation like documenting biodiversity, soil and nutrient management, shade regulation, economic analysis of production and coffee quality assessment. Long term hydrological studies on 7 farms in different agro climatic regions were undertaken documenting rainfall, interception and other hydrological observation. Daily rainfall records collected from 108 farmers some as old as 60 years for analysis of rainfall and farmers were informed of the rainfall analysis results. Project team facilitated the capacity building of farmers on the following issues:

- Traditional Ecological Knowledge of 120 farmers
- Biodiversity studies related to trees ,birds, epiphytes, microbes
- Soil Analysis and Economic surveys of reference farms (coffee, pepper, honey, wood)
- Coffee quality (Both on Arabica & Robusta, 150 Farms, cup testing at Coffee Board & Coffee lab)

5.1.2. Collaborations

i) Linkage with foreign Institutions and Teams.

Graduate and post graduate students from India and outside interacted with the project team and undertook studies on different aspects leading to Masters' and Doctoral degrees (Annexure 8). Twenty Seven guest lecturers and trainings were also conducted by visiting project team members to the staff and students of College of Forestry (Annexure 9). Training in field ecological studies was provided by the project team to 16 graduate students from the overseas Universities and Institutions viz., ETH, Switzerland; Universitat autonoma de Barcelona, Spain; University of Rhodes Island, USA; University of Iowa, USA; University of Wales, Bangor; University of Leeds, UK and Agroparis Tech, Paris. Box 5 presents an example of such inter-institutional linkages.

Box 5: University of Leeds Student Projects: Status Report

Between 5th June and 15th July 2009, eight students from the University of Leeds visited the Kodagu landscape to carry out biodiversity-related studies. These studies were conducted as part of the students' Masters Dissertations. The students' work – a part of the "Linking biodiversity and ecosystem services in a global biodiversity hotspot" – was supported by the University of Leeds and the UK-India Collaborative Research Initiative, and was carried out in collaboration with Nature Conservation Foundation, Mysore, and CAFNET which is based at the College of Forestry, Ponampet. The work was carried out in forest fragments (sacred groves) and shade coffee plantations across five villages in the Virajpet Taluk of Kodagu District. The villages visited were (1) Heggala, (2) Betoli, (3) Arji, (4) Kadanur and (5) Betoli.

Details of student projects are provided in the list below. The students are presently analysing the data collected and preparing their thesis reports, which will be made available as and when they are submitted.

Name	Project
Linda Chepkorir Ruto Munyao	Effect of landuse change and habitat fragmentation on birds
Sophie Elizabeth Malone	Plant-pollinator interactions at fragment edges
Charlotte April Bickler	Plant-pollinator interactions at fragment edges
Justine Saelens	Diversity and abundance of epiphytes in forest fragments
Isabel Cristina Villasmil Munoz	Effect of landuse change and habitat fragmentation on bats
Reyna Clara O' Higgins	Herbaceous cover along trails in forest fragments
Shivani	Effect of landuse change and habitat fragmentation on butterflies

Figure 54: Capacity building of farmers at workshops (upper left), on site (upper right) or through face-to-face handing of results.

The salient results from the studies on Trees and birds on the farm, soil testing results, economics of production and cup quality were provided individually to each participating farmer. Most of this information was being provided to the farmers for the first time will help these farmers by empowering them towards better productivity and market access. The results provided also helped the farmers to know about the different ecosystem services provided by the coffee plantations and how to access better markets using these ecosystem services.

ii) Linkage with NCF Mysore & Rain Forest Alliance

The Nature Conservation Foundation, Mysore is an organization facilitating the Rain Forest Alliance certification in India. Project team actively collaborated with these two organizations for promoting certification of sustainable coffee production. Cafnet India team also participated in a satellite meetings by Rain Forest Alliance on the new proposal of climate plus for the Sustainable Agricultural Standards (SAS). In this meeting the team suggested that local indicators need to be developed and included for the certification standards and some of the parameters proposed are very difficult to quantify and monitor by the research teams and farmers.

1. Participation in workshop Local Indicator Workshop for Sustainable Coffee Production in India on October 30th 2010 in Madikeri
2. Participation in Certification workshop *Coffee and Conservation: fostering sustainable plantations and opportunities for certification* on 19th July 2010 (Monday) at the Planters Court, K.M. Road, Chikmagalur.
3. Participation in workshops at on Fostering sustainable agricultural practices for conservation in plantation landscapes of the Nilgiris: role of NGOs and conservation organizations 2nd February 2010.
4. Second Local Indicator Workshop for Sustainable Tea and Coffee Production in India on July 16th 2010 in the Nilgiris.
5. Workshop on High value ecosystems in plantation landscapes of India Workshop and consultation with subject experts 11 February 2011, Friday National Centre for Biological Sciences, GKVK Campus, Hebbal, Bangalore .
6. Participation in Climate Plus programme organized during ASIC in Bali

iii) Linkage with Indian Institute of plantation Management (IIPM)

IIPM invited project team as resource persons for the training programmes Empowering Growers' Collectives as Business Unit' held in collaboration with Coffee Board at Mudigere on 10th Dec. 2010.Kushalnagar 14th Dec.2010 and Virajpet 16th Dec.2010.

iv) Linkages with International service Clubs

Project team interacted with members of Rotary Club of Gonikoppa and motivated 6 members to participate in certification programme. A training programme was jointly organized with Rotary Club of Madikeri for club members. Members of Lions Club of Gonikoppal and Jaycees Club at Ponnampet undertook joint activities on sustainable coffee production.

Activity 5.2. Dissemination of methods and lessons.

We present here our activities of dissemination and outreach to regional and international forum. These activities are classified according to the location of the conference attended. However, owing to their particular relevance to the project, there are separate sections devoted to the two CAFNET Melas (October 2008 and Spring 2011).

Central America

The starting year saw the participation of the Indian team to two major events organized at CATIE (Costa Rica):

1. the first regional meet of CAFNET from 24.9.2007 till 27.9.2007
2. and the "Second International Symposium on Multi-Strata Agro forestry Systems with Perennial Crops" from 17.09 to 22.9.2007.

The theme for the event was **"***Making ecosystem services count for farmers, consumers and the environment"***.** Dr. C.G. Kushalappa, Associate Professor, Department of Forest Biology and Tree Improvement, College of Forestry, Ponnmapet and the Regional Co-ordinator of CAFNET (India), leader of Coffee Board of India team, Dr. Raghuramalu and leader of French Institute Pondicherry team Dr. Claude Garcia represented India region in the first regional meet of CAFNET held at CATIE, Turiallba, Coasta Rica. This meeting provided an opportunity to present highlights of our work and meet and learn about the work being undertaken in other regional centers in Africa and Central America. Presentation by leaders of Costa Rica, Guatemala, Nicaragua from Central America highlighted various issues related to coffee production in this countries.

Our team presented the salient aspects of Indian coffee industry and how our system is not only economically stable but ecologically sustainable. We emphasized that the multistoried agro forest of Kodagu is an ideal model for providing not only quality coffee but a range of eco-system services. We highlighted our work in the Kavery water shed area and the work undertaken by the team in documentation of traditional ecological knowledge and the use of Geographical Information System for selection of study area and monitoring landscape and land use changes. The constitution of stakeholder committee comprising of diverse stake holder was highlighted and the inputs provided by the stake holder committee which has helped in identifying key issues and planning the different activities, was appreciated by the participants.

The following papers were presented in the Symposium:

1. Impact of the canopy cover on the productivity and quality of shade grown coffee in Kodagu district, South India. By Satish, C.G., Kushalappa and K.M. Nanaya.
2. Land tenure systems: A key to conserve tree diversity in multistoryed Coffee Agroforests of Kodagu, Central Western Ghats, India. By, B.N.Satish, C.G. Kushalappa and Claude Garcia.

Our team visited coffee plantation managed by small growers and large companies and organic coffee plantation in Costa Rica. The team also visited to large co-operatives which were very active and got first hand information on processing, cup tasting, and value addition, social and environmental projects being undertaken by these co-operatives. We also visited a small co-operative which has undertaken Eco-tourism and organic coffee production activities.

To conclude, the visit of Indian team to Costa Rica was very productive to set first hand information on coffee industry in Costa Rica and also gain very valuable information on coffee production systems in Central America and East Africa. The visit was also very helpful to highlight the unique features of Indian Coffee Industry.

Africa

Year 2009 coincided with the organization of the 2nd world congress of Agroforestry from 14th to 30th Aug 09 at ICRAF, the regional CAFNET partner. The annual CAFNET workshop was hence organized almost as a side event to this globally relevant conference.

The visit to Kenya to attend the third CAFNET workshop and the second World Congress on Agro forestry from 14th till 30th August 2009 was a productive visit for the team since we could visit the areas of coffee and agricultural production in Kenya and interact with range of stakeholders associated with agriculture and natural resources management. As part of third CAFNET workshop, our team visited Nyeri and Embu in the Central Provenance in Kenya from 16th to 22nd August which are known for high quality Arabica coffee production. We presented highlights from our study in the workshop in which teams from other 7 countries participated to exchange information on the progress of work and issues related to sustainable coffee production. The issues discussed in the meeting included value chain, cooperatives and eco-certification labels for coffee, integration of local knowledge in arriving at best management practices, hydrology and carbon sequestration studies and future activities of the project.

On farm, we were shown the different crop diversifications that were being undertaken by the Kenyan cooperatives to sensitize farmers on the need for diversification for sustaining coffee production system through integration of trees, crops and livestock.

In the second world Congress on Agroforestry held in the United Nations Complex at Nairobi with 1200 delegates from 96 countries taking part, our team from India presented 12 papers which included 6 oral presentations and 6 posters. Dr Philippe Vaast, Coordinator and Dr. CG Kushalappa Regional Coordinator, India, chaired independent sessions in the event.

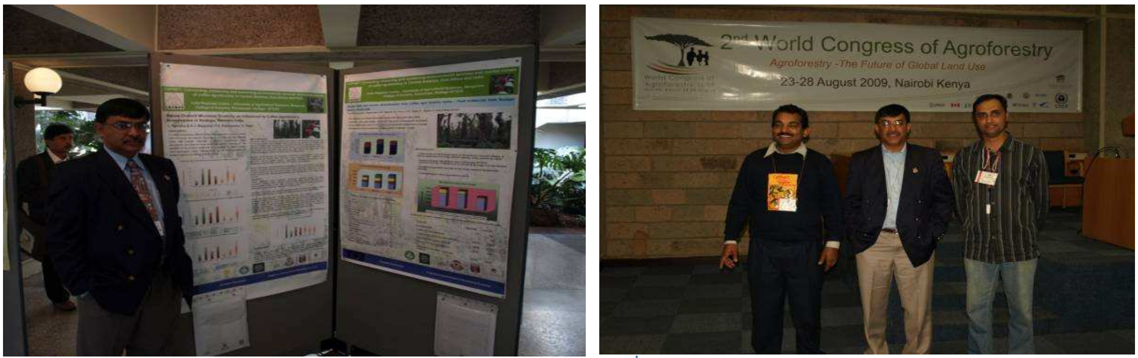


Figure 55: Delegates from the Indian CAFNET team attend the 2nd World Congress of Agroforestry (Nairobi, Kenya).

Following presentations and posters were presented at the Congress:

1. *Effects of tree composition on epiphytes in coffee agroforestry systems of Kodagu, India.* **Presenter:** Dr. Mohana, G.S., University of Agricultural Sciences, Bangalore.

The study tried to answer three questions. 1) Whether the increase in canopy cover has any impact on ephiphyte abundance 2) Is there any relationship between epiphytes and host preference 3) DO vegetation type have any impact on distribution and abundance of these species. From the study it was evident that there exists a positive relationship between canopy cover and abundance and in fact, at around 50-75 % of canopy cover, highest abundance was seen. Some hosts such as *Syzigium cuminii* seem to host large number and diversity of epiphytes in both the vegetation types. However, there was a clear cut difference between evergreen and moist deciduous vegetations with respect to epiphytic abundance.

2. *Avifaunal Diversity Studies in Coffee plantations with Different Shade Management in Kodagu, Western Ghats, India.* **Presenter:** Dr.Claude Garcia, CIRAD France and FIP India College of Forestry, UAS Bangalore.

This talk concentrated on the impact of management on avifaunal diversity because this helps as a tool to monitor forest and agroforestry systems. It also reflects ecological sustainability of the production system. It was evident from the study that species richness of birds increases with the increase in the number of native trees. Further tree diversity increase will have positive impact on diversity of birds. The Shanon diversity of birds decreased with the increase in canopy diversity. This is attributed to the artifact because of mobile observation of birds by the researcher. Further, it was found in the study that increase in the number of exotic species Grevilia robusta decreased the diversity of birds. The study has also identified 4 of the endemic species of birds reported for the Western Ghats.

3. *Patterns of tree biodiversity in coffee agroforestry systems of the Kodagu district, Western Ghats, India* (Oral Presentation) C. Garcia, C.Nath, K.M. Nanaya, C.G. Kushalappa and P.Vaast.
4. *The wicked elephant of the East: coping with human elephant conflicts in coffee agroforestry landscapes in Kodagu (India)*. (Oral Presentation) P. Bal, C. Nath, C.G. Kushalappa and C. Garcia.
5. *Ecological and Economic analysis of Coffee Agroforestry Systems: Case study from Central Western Ghats, India.*(Oral in Session 1) Dr C.G Kushalappa
6. *Shade trees and income diversification from coffee agro forestry farms - Field evidences from Kodagu district, South India.* A.N. Chethana, H.N.Ragavendra, Dr.N.Nagaraj Dr.C.P.Gracy Dr. Philippe Vaast, Dr.C.Garcia & Dr.D.Marie-Vivien (Poster)
7. *Below Ground Microbial Diversity as Influenced by Coffee Agroforestry Ecosystems in Kodagu, Western India.* C.Raveesh, Dr.J.Bagyaraj, Dr.Philippe Vaast (Poster)

Asia

Dissemination in Asia has been carried out through two major channels: participation to the 23rd ASIC Conference in Bali in 2010 and the CAFNET Mela held on the site of the research, in Kodagu on April 2011.

The theme of 23rd ASIC (Bali) was on Coffee and Health and Climate Change –Sustainability and was very well organized by the Indonesian Coffee and Cocoa Research Institute which is celebrating one hundred years of service to coffee stakeholders in Indonesia.

Figure 56: CAFNET Delegates attend the ASIC 2010 Conference in Bali.

On an invitation extended by the organizing committee of the 23rd International Conference of Coffee Science (ASIC), Dr.C.G.Kushalppa Professor and Head Department of Forest Biology and Tree Improvement and Regional Co-ordinator (India) for CAFNET Project attended the event held at Bali, Indonesia from 3rd to 9th October 2010. Other members of CAFNET India team who took part in the event were Dr. Raghuramulu, Joint Director Coffee Board of India and Dr. Claude Garcia, Team leader from French Institute of Pondicherry. Totally two oral presentations and four posters based on the work being undertaken by the project team was presented in this important gathering of coffee researchers, traders, curers and exporters from all the major coffee producing and consuming countries in the world.

Dr.C.G.Kushalappa, presented a oral presentation on **Coffee Agroforestry in Kodagu, Western Ghats, India- Need for Conservation to sustain livelihoods.** In these presentations the studies being undertaken in Kodagu district the only CAFNET site in India by the multidisciplinary team of researchers in 38 villages in the Kavery Watershed region was highlighted. Ecological and Socio-economic studies are being undertaken for the first time in the region to document and value the ecosystem services being offered by coffee based agroforestry systems and efforts that are underway to educate farmers and to form groups to add value to coffee through eco certification was emphasized in the presentation. The efforts of multi disciplinary study in providing much needed information on role of coffee plantations in providing key ecosystem services and to formulate guidelines for sustainable coffee cultivation to help the farmers through value addition and better access to markets were issues on which discussions were held among the delegates.

During the poster session held on 5th October Dr.C.G.Kushalappa and Dr.Raghuramullu explained to the delegates the outcomes of the studies undertaken by the Cafnet team on impact of shade cover on water balance, carbon sequestration and quality of coffee. The poster on studies undertaken by ETH Switzerland on impact of shade cover on pollination services was also presented and explained by the project team. The interactions held with visiting delegates and also opportunity to know about work being undertaken by teams in other coffee growing regions was of immense use for the project team and will help in establishing links with other teams working on valuation of ecosystem services and certification of sustainable coffee production.

CAFNET MELA-1

Proceedings.

The second international CAFNET workshop was organised in India, hosted at the college of forestry, Ponampet.

Box 6: Pictures from CAFNET Mela I

Delegates and representatives from the three CAFNET sites (Central America, Africa and India were present). We had technical sessions for all the activities of the project, including AKT (coordinated by Dr. Fergus Sinclair); Biodiversity (chaired by Dr. Claude Garcia) and discussions regarding relevance of common protocols and first results. The session on Economical aspects was chaired by Dr. Nagaraj. Of particular interest to the session was the presentation by Gabriela Soto from Costa Rica on *Value chain and cost/benefits of certifications in Costa Rica, Nicaragua and Guatemala.* The technical sessions were followed by a field trip, with an overview of the Kodagu Landscape, visits to Self Help Groups and Women cooperatives in Talakavery; a visit to Bettageri- Medium and Small farmers and to the cardamom plantations at Appangala. The delegates finally visited estates in and around Chettalli (Coffee Board Research Station), the Tata Coffee plantations, the largest land-owner in Kodagu and an organic plantation in Polibetta. The last day was devoted to sessions on *Access to Eco-market* and plenary discussions on traders and farmers' strategies for access to eco-markets with delegates and invited participants from Tata coffee, Coffee societies, Phalada, Ned commodities, ABC, KMFT and Home stay Associations.

CAFNET MELA-2

Proceedings .

The final workshop of Indian component of CAFNET project was organized as 'CAFNET Mela-2011' at Ponnampet, Kodagu district on the 14th and 15th of April 2011. The main objective of the workshop *was to disseminate the important outcomes of the project among the coffee sector stakeholders and to discuss* future approaches for utilizing the major leads obtained from the project towards rewarding the sustainable practices adopted by the growers in Kavery watershed in Kodagu district in particular and coffee producers in other regions with similar conditions. *Mela* is a Sanskrit word meaning 'gathering' or 'to meet' or a Fair.

An Organizing Committee headed by the Dean, Forestry College, UASB, Ponnampet and comprising of representatives of Coffee Board of India and French Institute of Pondicherry, Steering Committee members and other stakeholders took up the major responsibility for organizing the CAFNET Mela-2011. The organizing committee met six times between October 2010 and April 2011 to plan and coordinate arrangements for the mela.

CAFNET Mela-2011 was inaugurated by Dr.K.Narayana Gowda, Vice Chancellor of the University of Agricultural Sciences (Bangalore) in the presence of Dr.Jayarama, Director of Research, Coffee Board and Prof.Marimoutau, Director, French Institute, Pondicherry representing the two regional partners. Dr.N.A.Prakash, Dean, College of Forestry and Chairman, Organizing committee welcomed the gathering and Dr.C.G.Kushalappa, Regional coordinator India presented the highlights of the project and important outcomes based on the studies undertaken by the project team. The handouts on important outcomes of different studies like Bio-diversity, water dynamics, carbon sequestration, rainfall analysis, coffee quality, value chain analysis etc. undertaken by the project team were released by Prof.Marimoutau who expressed his happiness about the manner in which this collaborative was implemented and requested the farmers to make use of the recommendations emanating from the CAFNET project to grow coffee in a sustainable manner. Dr.Jayarama released the Field Guide on 'Trees of coffee based agro forestry systems in Kodagu' and complimented the team on the work undertaken and also for coming out with this field guide which will be useful for coffee farmers, researchers and extension workers to help them in identification of trees in coffee areas and in the process help in their protection. Dr.Narayana Gowda while releasing the book of Compilation of Farmers Knowledge complimented the team on the effort of not only documenting the local knowledge available in coffee areas and stressed that this is vital for protection of environment. He assured the support of the University in undertaking farmers friendly programmes which will bring together the researchers and farmers. The inaugural ceremony concluded with vote of thanks by Dr.Raghuramulu, Joint Director (Research) and representative of Coffee Board in the Project.

Figure 57: The inaugural session of the CAFNET Mela was followed by technical sessions.

Earlier in the day, an Exhibition showcasing technologies for coffee and associated crops, organic inputs, farm machineries suitable for coffee estates and certification aspects was inaugurated by local elected representatives. About 40 stalls were put up at the exhibition which was attended by a large number of coffee growers and other stakeholders from Kodagu district and other regions.

Figure 58: The exhibition of the CAFNET Mela.

Technical sessions:

One of the major objectives of the CAFNET Mela was to share the important research highlights of the project with different stakeholders who had participated in the project and also with other stakeholders of coffee sector. Besides, the workshop was also intended to provide an interface between scientists, coffee growers, policy makers to discuss their views on sustainable practices. Hands on training programmes were also organized for the benefit of participating farmers on the subject of certification, roasting, brewing & cup quality assessment etc. All these activities have been grouped under different technical sessions.

Technical session I: 14th April 2011 Afternoon

The technical session-I was mainly dedicated towards sharing of important findings of various studies conducted under CAFNET project. Presentations were made by the respective activity leaders on the following topics:

1. Local traditional knowledge and Agro ecological Knowledge Tool – *Dr. Mohana G.S.*

2. Biodiversity and shade management in Coffee – *Dr. Claude Garcia*
3. Carbon, water, quality studies in CAS of Kodagu – *Dr. Kushalappa, C.G*
4. Eco– certification and Value addition in Coffee – *Dr. Raghuramulu, Y*

The resource persons shared the important highlights of the work undertaken and also the handouts prepared by the project team was distributed to the participants. Discussions were held on the outputs from the project and how some of these results could be used in sustainable coffee production.

Figure 59: Technical sessions of the CAFNET Mela.

Technical session II: 15th April 2011 Forenoon

In this session, the coffee farmers, researchers and other stakeholders were brought under common platform to share their experiences in different aspects of sustainable coffee production. The organizing committee had identified following areas for the farmer-scientist interaction meet and the details of the sessions held are hereunder:

1. **Session on sustainable coffee production and shade management:** *Inaugurated By Mrs.Tara Aiyamma, Member, Coffee Board of India. Mr.Bose Mandanna, former vice chairman of coffee board and progressive farmer and Mr.Ponnanna , Joint Director (Extension), Coffee Board were roped in as subject experts. Discussions covered wide range of topics like shade management, mechanization, nutrient management, crop improvement and post harvest management.*

Figure 60: Discussions on the afternoon sessions.

2. **Session on value chain and marketing:** *Inaugurated by Mr. Nanda Beliappa, Member, Coffee Board of India. Mr.B.B.Subbaiah, former member of Coffee Board moderated the session and Mr.Harry Thammaiah, President of Cherambane Certified Farmers Group shared the experiences of his group in eco-certification of estates. Discussions were mainly centered on opportunities and constraints towards certification of estates.*

Figure 61: Value chain and marketing discussions.

3. Session on quality improvement and specialty coffee: Robusta cherry. Inaugurated by Mrs. Chandramathi Ganesh, Member, Coffee Board of India. Dr.Raghurammulu, Joint Director (Research), Coffee Board was the subject expert and Mr.A.A.Ponnappa from BBTC Plantations represented the farmer group. Mr. Ponnappa highlighted the efforts undertaken by BBTC group to add value to the coffee grown in Kodagu district and requested farmers to join hands among themselves and with the company to give more visibility to coffees from India. Information was also provided on the various activities undertaken by Coffee Board to improvement of coffee quality and promotion of Indian specialty coffees in the world market.

Figure 62: Quality improvement attracted a lot of attention.

Session-III: Hand on Training sessions - 15th April 2011 (2-4 pm)

The following hands on training sessions were held for the benefit of participating farmers and other stakeholders.

1. Eco-certification conducted by representative of M/s.IMO Control Pvt.Ltd. an international certifying agency and facilitated by Ecom Gill Pvt. Ltd and Ned

Commodities India Pvt Ltd the two important traders of certified coffees from India. Large number of farmers took part in the programme to know the different aspects of eco certification and how to participate in the programme.

2. Cup tasting training was conducted by Mr.Jayaram balyaya, Coffee Quality Specialist from Coffee Research Sub Station, Chettali where in a good number of participants was provided hands on training in roasting, brewing and assessing the quality of coffee through cupping.

3. Eco tourism session was conducted by Kodagu Tourism Promotion council to share the important issues related to establishment of ecotourism ventures within the coffee plantations as a key element of diversification and sustainability.

Felicitations to certified farmers

One of the key areas of CAFNET project was to work with farmers groups for production and marketing of certified coffees. Under this programme, the project team undertook formation of farmers groups across the Kavery watershed in Kodagu district and linking these farmers groups to major buyers of certified coffees for arranging certification of their holdings for Rainforest Alliance and UTZ Certified programmes. Two major export firms viz., M/s. Ecom Gill Coffee Trading Company and M/s. Ned Commodities India Ltd. have come forward readily to assist the farmers groups in eco-certification and purchase of certified coffees. The CAFNET project team had successfully organized formation of seven farmers groups in Kodagu district after working for two years.

The farmers from these seven certified groups were felicitated by at the CAFNET Mela-2011 to recognize their active participation in certification programmes.

Figure 63: Certified farmers are honored.

Cultural shows

As part of the CAFNET Mela cultural performances were organized to showcase the theme of the CAFNET project on linking Kavery and Coffee. Musical performance by Ninada Troupe from Ponnmapet for the inauguration and dance drama by Special children form Swastha, Suntikoppa on environment protection provided the delegates a glimpse of the cultural richness of the communities and landscape of Kodagu.

Figure 64: Cultural program to close two busy days of discussions.

Sponsored programmes

Ecom Gill Trading Company sponsored a dinner interaction for all the participating delegates at Kodagu Sports Club, Ponnmapet. Representative of the company highlighted the activities being undertaken by the company under Sustainable Agricultural Services and the work of supporting eco-certification in Kodagu in association with CAFNET Project. Ned commodities and ABC Coffee Company also sponsored part of the programme and the activities being undertaken by them to promote sustainable coffee production.

Valedictory Programme

This session was chaired by Dr.P.G.Chengappa former Vice Chancellor of University of Agricultural Sciences, Bangalore which is the regional coordinating institute of CAFNET Project in India. Prof.Marimottu, Director, French Institute of Pondicherry and Dr.N.A.Prakash, dean, College of Forestry were also present. Dr.Chengappa, who was closely associated with the project right from the inception, suggested that the farmers should join hands to not only produce quality coffee but also to market their coffees innovatively to move up in the value chain and realize better returns. He complimented the CAFNET team for undertaking this project, which is first of its kind in documenting the eco-system services from Coffee Agro forests in India and probably in Asia. He modulated the final session where discussions were held on the important outcomes from the CAFNET project and future course of actions.

Important recommendations of CAFNET Mela-2011

Some of the important recommendations that emerged during the valedictory session are summarized below:

1. The traditional ecological knowledge of the farmers and stakeholders as documented by the project team is quite substantial and useful for the future generation coffee planters and stakeholders.
2. Based on the studies carried out on Biodiversity it is evident that though there are around 250 trees in the coffee plantations, Silver Oak, an exotic species is the most dominant tree. The results from studies on birds and small mammals, water dynamics and coffee quality indicated that the importance of native trees in coffee holdings. Hence, the Silver Oak population in a given holding should be limited to a threshold of 30% within coffee blocks, excluding the edges of the management block, so as to retain the habitat for the birds and other flora and fauna in coffee estates. This threshold could be taken up as a biodiversity indicator by certifying agencies. Efforts should also be taken to publicize the impact of Silver Oak on biodiversity and coffee quality.
3. The studies on Carbon stocks indicated that carbon stocks are highest in natural forest followed by Arabica plantations and then by Robusta plantations. Holdings with native tree cover stored more carbon than those with Silver oak dominated shade. However, these results need to be confirmed through further studies to quantify the carbon sequestration abilities of coffee plantations.
4. The studies undertaken by the project team on rainfall behavior based on the analysis of rainfall data of last 60 years indicated shortening of monsoon period over the years and that there is a cycle of rainfall pattern with a possible drought every 12-14 years. Based on the trend, the next dry year may occur anywhere between 2014 to 2016 in Kodagu district.
5. Tradeoff between coffee production and water recharge could be the key issue and there is a need to value the service and provide payments to farmers based both on Quality and quantity of water.
6. To improve the water recharge in the landscape it was proposed to provide Incentive for rice cultivation and collective incentive for watershed management for the entire community rather than individual benefits.

6. The issue of tree rights and ownership is an important one and the results of Role playing exercise involving coffee farmers clearly indicate that there is a trade off between economic sustainability and maintenance of native trees. The issue of providing the tree rights to farmers is in the hands of local governments. Although many farmers are interested to plant native trees, non-availability of

saplings of native species has been identified as major constraint. Hence, the Forest department should establish nurseries and supply seedlings of native trees.

7. Incentives should be provided to the farmers who retain the natural forests amidst their plantations in the form of payments or tax incentives. Community managed sacred forests should also get incentives for protection.

8. Eco certification is a good tool which will prepare the farmers for production of sustainable coffee and greater efforts need to be undertaken by the Coffee Board to promote the concept of group certification. Increasing the bargaining power of certified farmer group could be accomplished by creating federations of certified farmer groups.

9. Further work to valuate the different services provided by coffee agro-forests documented by the CAFNET project team needs to be carried out to translate these services into Payments for Ecosystem Services (PES).

Finally, the CAFNET Mela-2011 was a very productive event since the different stakeholders involved in production of coffee in Kodagu district participated. About 1500 participants including 800 farmers, 27 exhibitors, scientists and extension personnel of Coffee Board, scientists/ students from Universities, representatives of Private plantation companies, Members of Coffee Board and representatives of local bodies and members of media attended the two day event. The Mela was successful in highlighting the work carried out under CAFNET project during the last four years in documenting the ecosystem services of coffee agro-forests of Kodagu district, which is now recognized as one of the most diverse coffee systems in the world and to spread the sustainable image of Indian coffee.

Future activities

University of Agricultural Sciences (Bangalore):

- Translation of handouts in local language.
- Reprinting of the field guide to trees of agroforestry.
- Continued collaboration with Ecomgill India Pvt Ltd and Ned commodities India Pvt Ltd and any other traders to create awareness among farmer groups and facilitate formation of farmer groups for sustainable coffee production through eco certification.
- Working with Coffee Board research and extension teams to support activities related to sustainable coffee production through ecocertification and value addition activities. Continue discussion with coffee Board to scale up some of the

results from the project as policy guidelines for promoting sustainable coffee production.

- Efforts to share project results with United Planters Association of South India(UPASI) , Karnataka Planters Association(KPA), Coorg Planters Association (CPA) , Coorg Coffee Growers Coopertive Society , Coorg Womens coffee Awarness Body , Home stay owners Association.
- Continue efforts of collaborative research and outreach programmes on sustainable coffee production. In this regard following developments have already been initiated.
    - Workshop on bird friendly coffee with Smithsonian Migratory Bird Center and Aditi Organics, Bangalore.
    - Project with Department of Geography University of Cambridge and CAFNET on farmers perception on certification.
- Collaboration with Institute of Socio Economic change ,Bangalore on economic valuation of ecosystem services.

Coffee Board

The Coffee Board itself is taking up two separate studies one each on 'Prospectives for certified coffees production in India' and 'Carbon Mapping across coffee chain'. Presently, the Board is in the process of inviting proposals from independent consulting agencies which have expertise in the field. The outcomes from these studies will be very useful in promotion of Indian coffees as well as linking up environmental services to the payments.

French Institute of Pondicherry

The Institute maintains the webpage of the project, where all the results have been uploaded for dissemination. The research team will continue the value addition of the scientific database generated though the project. This phase will last probably one more year.

Figure 65: The CAFNET India Team (2008 and 2011).

References

Ambinakudige, S., and B. N. Satish. 2009. Comparing tree diversity and composition in coffee farms and sacred forests in the Western Ghats of India. Biodiversity and Conservation **18**:14.

Bal, P., C. Nath, and C. Garcia. 2008. Drivers of human elephant interactions in coffee agro-forestry landscapes in Kodagu (Western Ghats), India. Page 67. French Institute of Pondicherry, Pondicherry.

Bal, P., C. D. Nath, K. M. Nanaya, C. G. Kushalappa, and C. Garcia. 2011. Elephants Also Like Coffee: Trends and Drivers of Human–Elephant Conflicts in Coffee Agroforestry Landscapes of Kodagu, Western Ghats, India. Environmental Management **47**:789.

Bhagwat, S. 2002. Biodiversity and Conservation of a Cultural Landscape in the Western Ghats of India. Page 212. Linacre College and Oxford Forestry Institute, Oxford.

Chao, A., and S. M. Lee. 1992. Estimating the number of classes via sample coverage. Journal of the American Statistical Association **87**:210-217.

Chethana, A. N., N.Nagaraj, P. G. Chengappa, and C. P. Gracy. 2010. Geographical Indications for Kodagu Coffee - A Socio-economic Feasibility Analysis. Agricultural Economics Research Review **23**:97-103.

Coffee Board of India. 2011. Database on coffee. Page 109. Economic and Market Intelligence, Bangalore.

Decroix, M., and F. Chretien. 2007. Agriculture et Biodiversité. Caractérisation des systèmes agroforestiers à base de café. Page 210. Institut des Régions Chaudes, Montpellier.

Elouard, C., and C. Guilmoto. 2000. Vegetation Features in relation to Biogeography. Pages 25-155 in P. S. Ramakrishnan, editor. Mountain Biodiverisity, Land Use Dynamics and Traditional Ecological Knowledge. Oxford & IBH Publishing, New Delhi.

Garcia, C., S. Bhagwat, J. Ghazoul, K. M. Nanaya, C. Nath, C. G. Kushalappa, Y. Raghuramulu, R. Nasi, and P. Vaast. 2009. Biodiversity conservation in agricultural landscapes: challenges and opportunities of coffee agroforestry in the Western Ghats, India. Conservation Biology **24**:479-488.

Garcia, C., D. Marie-Vivien, C. Kushalappa, P. G. Chengappa, and K. M. Nanaya. 2007. Geographical Indications and Biodiversity in the Western Ghats, India. Can labeling benefit producers and the environment in a mountain agroforestry landscape? Mountain Research and Development **27**:206-210.

Garcia, C. A., S. A. Bhagwat, J. Ghazoul, C. D. Nath, M. N. Konerira, K. G. Cheppudira, Y. Raghuramulu, R. Nasi, and P. Vaast. 2010. Biodiversity conservation in agricultural landscapes: challenges and opportunities of coffee agroforests in the Western Ghats, India. Conservation Biology **24**:479-488.

Mercereau, D., and C. Vignault. 2008. Coffee Value Chain and Geographical Indications in India: Origin, reputation and marketing of Indian coffees. Page 151. CIRAD, Montpellier.

Moppert, B. 2000. The elaboration of the Landscape. Pages 42-44 in P. S. Ramakrishnan, U. M. Chandrashekara, C. Elouard, C. Z. Guilmoto, R. K. Maikhuri, K. S. Rao, S. Sankar, and K. G. Saxena, editors. Mountain Biodiversity, Land Use Dynamics, and Traditional Ecological Knowledge. Oxford & IBH Publishing, New Delhi.

Muthappa, P. P., P. G. Chengappa, and T. N. Prakash. 2001. A Resource Economic Study on Tree Diversity in Coffee Based Plantations in the Western Ghats Region of Karnataka. Page 47 in N. A. T. Project, editor. Department of Agricultural Economics, University of Agricultural Sciences, Bangalore, Bangalore.

Nath, C., R. Pélissier, B. Ramesh, and C. Garcia. 2011. Promoting native trees in shade coffee plantations of southern India: comparison of growth rates with the exotic *Grevillea robusta*. Agroforestry Systems:1-13.

Nath, C. D., R. Pélissier, and C. Garcia. 2009. Comparative efficiency and accuracy of variable area transects versus square plots for sampling tree diversity and density. Agroforestry Systems.

Nath, C. D., and R. Sukumar. 1998. Elephant -human conflict in Kodagu, Soutern India: distribution patterns, people's perceptions and mitigation methods. Page 63. Asian Elephant Conservation Centre, Bangalore.

Pascal, J. P. 1982. Forest Map of South India - Mercara Mysore. Karnataka and Kerala Forest Department and French Institute of Pondicherry.

Vendé, J. 2010. Management of tree cover in coffee-based agroforestry systems of Kodagu. ComMod approach for integrated renewable resources management. Page 186. AgroParisTech.

Figures

Boxes

Tables

ANNEXURES

Annex 1: Details of CAFNET team members

University of Agricultural Sciences (Bangalore)

The UASB is involved in CAFNET through the College of Forestry, Ponnampet, Kodagu and Department of Agricultural Economics at the main campus in Bangalore. The team involved in the project are:

1. Vice Chancellor of UASB: Dr.P.G.Chengappa,
2. Regional Coordinator: Dr.C.G.Kushalappa: Professor, College of Forestry, Ponnampet.
3. Asst. Regional Coordinator: Dr.Devkumar: Associate Professor, College of Forestry, Ponnampet.
4. Team Leader- AKT: Dr.G.S.Mohan: Assistant Professor, Agricultural Research Station ,Ponnampet.
5. Team Leader- Biodiversity inventory: Mr.M.N.Ramesh: Assistant Professor, College of Forestry, Ponnampet.
6. Action Leader, Biodiversity: Mr.Jade Gowda , Assistant Professor , College of Forestry, Ponnampet.
7. Team Leader, Valoration of environmental Services and value chain: Dr.N.Nagaraj, Professor, Dept. Of Agricultural Economics, UAS, GKVK Campus, Bangalore.
8. Action Leader, Valoration of environmental Services and value chain: Dr.C.P.Gracy, Professor, Dept. Of Agricultural Economics, UAS, GKVK Campus, Bangalore.

Research Personnel

Sl.No.	Designation	Name	Period of work
1	Research Associate	Somanna Chittiappa	July 2007- July 2011
2	Research Associate	Karun Chinnappa N	July 2007-Dec 2010
3	Research associate	Kamal Kumar HR	July 2007-Jan 2008
4	Senior Research Fellow	Sachin Kumar M D	March 2008-Dec 2010

Sl.No.	Designation	Name	Period of work
5	Senior Research Fellow	Pradeep D Cunha	Jan 2008- Dec 2009
6	Senior Research Fellow	Asha Tantry	March 2008-Aug 2010
7	Senior Research Fellow	Ravish C	Aug 2008- Apr2010
8	Senior Research Fellow	Vidya Rao	Mar 2009- Oct 2009
9	Senior Research Fellow	Malavika	Mar 2008-Aug 2008
10	Junior Research Fellow	Dileep Kumar EK	July 2007 – Jan 2008
11	Junior Research Fellow	Suresh NL	July 2007-Sept 2007
12	Junior Research Fellow	Sudheep NM	July 2007-Jan 2008
13	Junior Research Fellow	Kavana TS	Nov 2007-Aug 2008
14	Junior research Fellow	Poornika Rani BJ	Sep 2007 –Aug 2010
15	Junior Research Fellow	Bhuvaneshwari N	Mar 2008- May 2009
16	Junior Research Fellow	Vishnu priya	Jan 2009- June 2009
17	Junior Research Fellow	Raghavendra HN	Apr 2008-Dec 2008
18	Junior Research Fellow	Chethana	Sep 2007-Aug 2008
19	Junior Research Fellow	Ateeq Ahamed	Sep 2007-Aug 2008
20	Junior research Fellow	Prasanna Pathgar	Aug 2008- July 2009

Sl.No.	Designation	Name	Period of work
21	Junior research Fellow	Kishora Naik B	Aug 2008-July 2009
22	Junior Research Fellow	Manjunath	Sep 2007- July 2008
23	Junior Research Fellow	Harish TT	Sep 2007-July 2008
24	Junior Research Fellow	Ajay TL	Aug 2008- Oct 2008
25	Junior Research Fellow	Maruthy Gurav	Aug 2009-sep 2010
26	Junior Research Fellow	Swetha BA	Mar2010-May 2011

Service Personnel

Sl.No.	Designation	Name	Period of work
1	Accountant	Monnappa K B	Aug2007-Dec2010
2	Secretary	Rukmini K K	Mar2008-July 2011
3	Computer Assistant	Aiyappa AB	Agu 2007-Dec 2008
4	Computer Assistant	Kishori K A	Feb 2009-Dec 2010
5	Computer Assistant	Shilpa B P	Feb 2009
6	Office assistant	Ramesh N	Feb 2009-June2010
7	Office assistant	Menaka PV	Aug2007-Feb 2008
8	Field Assistant	Madeva	Aug2008-Feb2010
9	Field Assistant	Sharan Changappa B U	Nov2008-Dec 2010
10	Field Assistant	Jeevan N C	Nov2008-June2010

Sl.No.	Designation	Name	Period of work
11	Field Assistant	Sharath K B	Aug2009-June2010
12	Field Assistant	Swamy	July 2007-Jun2008
13	Field Assistant	Nijil	Sep2009-July2011
14	Field Assistant	Manju MR	May2008-Sep2008
15	Field Assistant	Umesh PK	May2008-Oct2008
16	Field Assistant	Shameer K	May2008-Nov 2008
17		Machaiah	Nov2009-June2010
18		Prathap	Nov2009-June2010
19	Driver	Mandanna K B	Aug2007-Dec 2010

Coffee Board of India

1. 1.Dr.Y.Raghuramullu- Joint Director (Research) and Team Leader
2. 2.Mr.Vasanth Kumar- Junior Research Fellow
3. 3.Dr.Prakasan-Deputy Director ,Coffee Research Sub Station Chettali
4. 4.Dr.Nagaraj – Soil Scientist
5. 5.Mr.Naveen- Driver till 2009
6. 6.Mr.Subbaih- Driver from 2009-2010

Research Team-IFP

1. Dr.Claude Garcia, Senior Scientist and Team Leader
2. Dr. Cheryl D. Nath, Post-Doc.
3. Nanaya K.M-Research Scholar and GIS expert
4. Vidya Rao, Senior Research Assistant
5. Jennu Kala M.G., Research Assistant
6. Aravajy S., Research Assistant
7. Ramalingam S., Research Assistant
8. Barathan N., Technical Assistant
9. A.T.Prathap, Field Assistant

Research Team-CIRAD

1. Dr. Philippe Vaast, Senior Scientist and general coordinator of Cafnet.
2. Fabien Charbonnier, research fellow on water issues.

Other Associates.

1. Dr.Fergus Sinclair – University of Wales, Bangor and ICRAF Kenya for AKT
2. Dr.Joseph Bagayaraj, UAS(B) and CNRBD Bangalore for Microbiology
3. Dr.Thomas Husband –University of Rhode Island ,US for Small Mammals
4. Dr.Sanajay Mollur- Zoo outreach, Coimbatore for Small Mammals
5. Sunalini Menon , Coffee Labs Bangalore for Coffee quality

Annex 2: List of target group.

Village	Name
Andagove	K. A. Umar Aji
Andagove	M.N. Monnappa
Andagove	Ratish
Arecad	Ballaranda Abitha
Arecad	Thamaiah T. D (Ranji)
Arecad	Kadumanda Sanjay Somaiah
Arji	Church poperty, Gilbert Dsilva
Arji	Kuttiah K. M.
Arji	B.R Manjappa
Athur Naller	Achaiah (Prasanth K.G.)
Athur Nallur	A.L R.M Nagappan
Athur Nallur	Palangappa A.P
B Badaga	Jorge Jacob (Suresh and Kishore writers)
B Badaga	K.M. Nandjunda
B Badaga	Kekada Subramania (Ramesh)
Birambada	Dr. Giriraj Kulkarni
Birambada	M.P. Chinappa
Birambada	U.M. Mustaffa
Bettageri	K.T. Aiyappa, (Prem)
Bettageri	Kuttappa. K. Sitavilla Estate

Village	Name
Bettageri	Kutratanda K Devappa
Biligeri	Mahabaleshwar Bhat
Biligeri	Devajana D. Jagadish
Biligeri	Irira Bopaiah
Cherala Srimangala	Kongetera D. Naniah
Cherala Srimangala	Kongetira M Appachu
Cherala Srimangala	brig K M Muthanna
Hachinadu	Col. Machaiah. B. M.
Hachinadu	Bopanna M. U.
Hachinadu	A. M. Thimaiah
Hakathor	Ammatanda Erappa
Hakathor	Kupadira Lava Appaji
Hakathor	Major Nanjappa
Heroor	Lingappa S. P
Heroor	H. B. Dharmappa
Heroor	D. K. Madappa
Hoddur	C. A. Achaiah
Hoddur	N. K. Nanjappa
Hoddur	T.S Gokula
Ire Valnudi	Sumathi Subbaiah
Ire Valnudi	Ajij Mohammad

Village	Name
Ire Valnudi	Nanaiah
Kudlur Chettally	S. M. Vimala W/o S. K. Motaiah
Kudlur Chettally	K.P Poovaiah
Kudlur Chettally	Denis John Peres
Kaggodlu	Dambekodi S Subash
Kaggodlu	Venkappa B. R.
Kaggodlu	Savithri, Chandrashekar
Kanthur	Pallangada Poovaiah
Kanthur	V.V.Ashwath kumar
Kanthur	Avaramadanda Kiran Cariappa
Karada	Iythichanda B Bhimaiah
Karada	Thammaiah, N.P
Karada	Aiyappa K.K
Karadigod	Karun Karambaiah
Karadigod	Poovaiah C.K
Karadigod	Elizabeth Dias
Karmad	Ponnajira. C. Bharath (Kishu)
Karmad	Mandepanda C. Vijaya, Kawadi (V)
Karmad	Kuttanda Baby Chengappa
Katakeri	Kombandra V. Machaiah
Katakeri	J. V. Ramesh

Village	Name
Katakeri	Hirendra Kamat
Kiggal	Pandigaranda M Machaiah(Babu)
Kiggal	Ichettira M Prabhakar
Kiggal	Pudiokada M Muttapa
Kirandadu	Mechanda S Devaiah
Kirandadu	T.K. Beemaiah
Kirandadu	Somaiah A.M
Kokeri	B.M. Belliappa
Kokeri	Uttaiah K.K
Kokeri	C.P.Kushalappa
Kolagadalu	Kondijalamana Radhakrishan
Kolagadalu	Manavattira Appaiah
Kolagadalu	Thamaiah B.b
Konanjageri	Bolakaranda A Nanaiah
Konanjageri	Mandanna B.M
Konanjageri	Kadira Umesh Palangappa
Kopatti	Kudiya K. Muddappa
Kopatti	Kattukattina Gokul
Kopatti	BCIL Plantation
Kottali	C.K. Ganapathy
Kottali	A.D.Mandanna (writer Ram Bhat)

Village	Name
Kottali	C.G. Mandanna
Mekur Hosakeri	Puliyanda Shoba Biddappa
Mekur Hosakeri	S. K. Mohan
Mekur Hosakeri	B.K Madappa
Mytadi	C.K. Joyappa
Mytadi	B.K. Suresh Chinnappa
Mytadi	I.K. Subbaiah
Naladi	P.B. Kaverappa
Naladi	P.K. Dali
Naladi	Dr E.K. Joseph
Nanjaraypatna	Yadav kumar (Brother Appanna)
Nanjaraypatna	Nitesh Nanjappa
Nanjaraypatna	K.T Chengappa
Ranga samudra	B. L. Mohan Raj
Ranga samudra	M. K. Thamaiah
Ranga samudra	Chandrashekar J. G.
Rasalpura	P T Raju
Rasalpura	Ganesh CK
Rasalpura	A M Khan
Sannapulikotu	K.B. Kallappa
Sannapulikotu	Kuyyamudi A Ramayya (Babu)

Village	Name
Sannapulikotu	P.B. Chinnappa
Seventh Hosakote	B. S. Vishwanath Rai
Seventh Hosakote	Jagdish Malappa D.B.
Seventh Hosakote	G.R.S. Saravagi
Singathur	P.c. Kusumakara
Singathur	Panathala vishwanath
Singathur	Beppamana monappa
Yedur	Dr. I. C. Bopanna
Yedur	Kumanda M Mudaiah

Annex 3: Composition of the steering committee

Si.No.	Name	Representation
1.	Mrs. Thara Aiyamma	Member, Coffee Board
2.	Mrs. Vimala Gopal	Member, Coffee Board till 2009
3.	Mr. P.A.Appachu	Member, Coffee Board till 2009
4.	Dr.S.M.Kaverappa	Member, Coffee Board till 2009
5.	Mr. Bose Mandanna	Former Vice Chairman, Coffee Board
6.	Mr. Rattageri	Deputy Director (Extension), Coffee Board, Virajpet
7.	Mr. Subbaiah B.B.	Member, Cauvery Family Committee
8.	Mr. C.M.Pemmaiah	Vice Chairman, Karnataka Planters Association
9.	Mr MB Ganapathy/Mr. Jushua Amrithraj	Senior manager/Manager,(R & D),TATA Coffee Limited, Pollibetta, Kodagu
10.	Dr. C.B.Prakashan/ Dr.Ramamurthy	Deputy Director (R), CRSS, Coffee Board, Chettalli,
11.	The President	Codagu Planters Association
12.	Col. C .P. Muthanna	President, Coorg Wildlife Society
13.	Station Head	Central Horticultural Experiment Research Station, Chettalli
14.	Mr. .M.B. Devaiah /Mr.K.C.Subramani	President, Kodagu Coffee Growers Cooperative Society, Madikeri
15.	Mr. K.N. Changappa	Director, The Coorg Foundation, Pollibetta, Kodagu
16.	Mrs. Chandramathy Ganesh	President, Coorg Women's Coffee Awareness Body and Member coffee

Si.No.	Name	Representation
		Board since 2010
17.	Mr.Nanda Beliappa	Member Coffee Board from 2010
18.	Mr. Fiayz Musa Kutty	Member Coffee Board from 2010
19.	Mr. Uthappa and Mr.Daya Achaya	Ecom Gill India Pvt Ltd.
20.	Mr,Sudhendra and Mr.Harish	Ned Commodities India Pvt.Ltd
21.	The President	Raja Rajeswari Women's coffee self help Group, Cherambane

In addition the following members of the project team will also be part of the Steering Committee.

1.	Dr. C.G.Kushalappa	Regional Coordinator	College of Forestry, Ponnampet
2.	Dr. Claude Garcia	Ecologist	French Institute, Pondicherry
3.	Dr. Raghuramulu	Joint Director	Coffee Board of India
4.	Dr.Philippe Vaast,	International Coordinator	CIRAD

Annex 4: Meetings by the steering committee 2007-2011.

Sl. NO.	Date	Venue	Event	Participants
1	3/2/2007	Coorg wildlife society hall,Madikeri	Steering committee meeting	27
2	5/7/2007	College of forestry,ponnampet	2nd steering committee meeting	17
3	8/20/2007	Shri Rama Trust Hall, Napoklu	Farmer and multisector steering committee interaction meet	43
4	5/13/2008	Kodavasamaj Napoklu	Farmer and multisector steering committee interaction meet	53
5	9/11/2008	CPA building Madikeri	Steering committee meeting	23
6	6/16/2009	College of forestry,ponnampet	CAFNET,Steering committee meeting	16
7	9/17/2009	CRSS, Chettali	Steering committee meeting	21
8	7/1/2010	College of forestry,ponnampet	Farmer and multisector steering committee interaction meet	18
9	12/22/2010	Rotary hall, Madikeri	Steering committee meeting	8
10	2/15/2011	College of forestry,ponnampet	CAFNET mela organising committee meeting	10
11	3/7/2011	College of forestry,ponnampet	CAFNET mela organising committee meeting	16
12	4/5/2011	College of forestry,ponnampet	CAFNET mela organising committee meeting	11

Annex 5: Villages covered for AKT in Kavery Watershed Area.

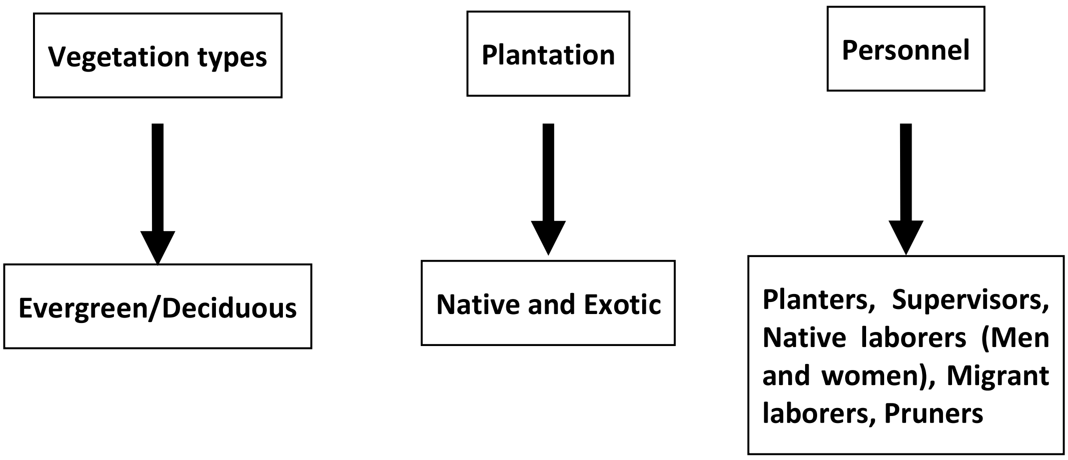
I. Evergreen area:

Bhagamandala, Sannapulikotu, Doddapulikotu, Ayyangeri, Napoklu , Kolakeri, Paliyataluk, Nelgi, Ballamavati, Barike, Emmemadu, Chettimani, Bengur-Ivattokkalu, Cherambane, Kakkabe, Marandoda, Nariandada, Cheyyandane, Yuvakapadi, Hoddur, Balmuri.

II. Moist deciduous area:

Bethri, Kiggal, Kondangeri, Byrambada, Pachchat, Achchinad, Kattemadu, Guyya, Arekad, Nelya-Hudikeri, Valnur, Tyagatoor, Hosapatna, Nanjarayapatna, Karadikodu, Rangasamudra.

Annex 6: Stratification for AKT diversity component.



Annex 7: Details of certified farmer groups promoted under CAFNET Project

Name of Group	Farmer code	Farm Name	Village	Total Farm Area (Ha)	Coffee Area (Ha)	Crop	Certified coffee (kgs) traded with Ecom till 31.05.11
SAS Cherambane Planters Group	1	Vanadurgi Estate	Kolagadalu	10.30	9.30	Robusta	
	2	Karthikeya	Cherambane	20.00	18.00	Robusta	17946
	3	Kallubane Estate	Kottur	11.00	8.00	Robusta	24735
	5	Jannath	Cherambane	12.50	12.00	Robusta	4138
	6	Manjunath Estate	Cherambane	4.00	2.00	Robusta	18510
	7	Brookside Estate	Cherambane	15.50	13.00	Robusta	5333
	8	Bhagavathi Estate	Cherambane	12.15	10.00	Both	43924
	9	Kushal Estate	Cherambane	9.31	6.07	Both	6530
		Sub Total		94.76	78.37		121116
SAS Shrigandha Eco Club	1		Somwarpet	4.80	4.80	Arabica	
	2	Mahalakshmi	Somwarpet	4.00	4.00	Arabica	
	3		Somwarpet	4.40	4.40	Arabica	
	4		Somwarpet	3.20	3.20	Arabica	
	5		Somwarpet	2.00	2.00	Arabica	
	6		Somwarpet	2.00	2.00	Arabica	
AS Shri gand ha Eco Club	7		Somwarpet	1.60	1.60	Arabica	

Name of Group	Farmer code	Farm Name	Village	Total Farm Area (Ha)	Coffee Area (Ha)	Crop	Certified coffee (kgs) traded with Ecom till 31.05.11
	8	Hosabeedu	Somwarpet	5.60	5.60	Both	
	9		Somwarpet	4.80	4.80	Arabica	2735
	10		Somwarpet	4.80	4.80	Arabica	
	11		Somwarpet	0.80	0.80	Arabica	4969
	12		Somwarpet	1.60	1.60	Arabica	
	13		Somwarpet	0.80	0.80	Arabica	
	14		Somwarpet	4.04	4.04	Arabica	
	15		Somwarpet	2.00	2.00	Arabica	
	16		Somwarpet	1.60	1.60	Arabica	
	17	Eswara	Somwarpet	4.80	4.80	Arabica	
	18	Sharadha	Somwarpet	4.00	4.00	Arabica	
	19		Somwarpet	1.60	1.60	Arabica	6607
	20		Somwarpet	2.00	2.00	Arabica	
	21		Somwarpet	3.20	3.20	Both	
	22	Hally byle	Somwarpet	7.20	7.20	Both	
	23		Somwarpet	14.00	14.00	Arabica	902
SAS Shrigandha Eco Club	24		Somwarpet	3.24	3.24	Arabica	

Name of Group	Farmer code	Farm Name	Village	Total Farm Area (Ha)	Coffee Area (Ha)	Crop	Certified coffee (kgs) traded with Ecom till 31.05.11
	25		Somwarpet	2.02	2.02	Arabica	2303
		Sub Total		90.10	90.10		17516
Kirandad Group	1	Rock Hill	Parane	7.29	8.10	Robusta	
	2		Kirundadu	8.10	4.05	Robusta	
	3		Kirundadu	4.05	4.86	Robusta	
	4		Kirundadu	2.43	2.43	Robusta	
	5	Balamudi	Kirundadu	4.05	4.05	Robusta	
	6	Girija	Kirundadu	4.86	4.86	Robusta	
	7		Kirundadu	6.07	6.07	Robusta	
	8		Kirundadu	3.64	3.64	Robusta	
	9	Hithlu	Kirundadu	5.26	5.26	Robusta	
		Sub Total		45.75	43.32		
Valnoor Farmers Group	1	Silver mist	Valnoor	24.70	23.89	Both	
	2	Ammangala	Valnoor	8.00	7.29	Robusta	21192
	3	Ashish	Valnoor	24.29	24.29	Robusta	24409
	4	Trust land	Valnoor	12.15	12.15	Both	12148
aln oo r Far me rs Gr ou p	5		Valnoor thyagathur	20.24	20.24	Both	24850

Name of Group	Farmer code	Farm Name	Village	Total Farm Area (Ha)	Coffee Area (Ha)	Crop	Certified coffee (kgs) traded with Ecom till 31.05.11
	6	Chamundi	Nanjarayapatna	8.10	8.91	Robusta	
	7		Nanjarayapatna	2.02	2.02	Robusta	
	8	Nalini	Nanjarayapatna	4.86	4.86	Robusta	
	9	Apputa	Nanjarayapatna	16.19	16.19	Robusta	12410
	10		Nanjarayapatna	5.26	5.26	Robusta	
		Sub Total		125.81	125.10		95009
Siddapur Farmers Group	1	Madura	Arecad	6.48	6.48	Robusta	
	2	River Bend	Guyya	16.19	16.19	Robusta	5020
	3	Ganesh	Guyya	10.53	10.53	Both	14990
	4	River Side	Siddapur	16.19	16.19	Robusta	
	5	Bhanangala	Siddapur	8.91	8.91	Robusta	
	6	Karinjane	Arecad	16.19	16.19	Robusta	
	7	Vijaya	Guyya	20.20	19.43	Both	25040
		Sub Total		94.69	93.93		45050
Begur Farmers Group	1	Shree Shabali Plantation	Betoli	4.86	4.86	Robusta	
	2	pradeep	Betoli	2.83	2.83	Robusta	15090
egur Far mer s Gro up	3	Gangadhar	Begur	3.24	3.24	Robusta	

Name of Group	Farmer code	Farm Name	Village	Total Farm Area (Ha)	Coffee Area (Ha)	Crop	Certified coffee (kgs) traded with Ecom till 31.05.11
	4	Poolemad	Begur	4.86	4.86	Robusta	
	5	Raghu	Begur	4.86	4.86	Robusta	
	6	Mundekad	Begur	8.10	4.86	Robusta	
	7	Bhoothankad	Begur	4.86	4.86	Robusta	7500
	8	Chandra	Begur	3.44	3.44	Robusta	
	9	Laxmi Estate	Begur	2.02	2.02	Robusta	5089
	10	Manjunatha	Begur	12.15	8.90	Robusta	
		Sub Total		51.22	44.73		27679
Grand Total	70			953.45	906.37		306370

Annex 8: Masters' and Doctoral degrees

Total Number of Masters Students: 20

Total Number of PhD students: 3

Affiliated PhD students: 2

Students from UAS(B)

1. HAREESH, H.T., 2009, Avifaunal diversity studies in coffee plantations with different shade management in Kodagu, Central Western Ghats, Master thesis in Forestry, UAS Bangalore, India,112p.
2. MANJUNATHA, M.,2009, Assessment of carbon sequestration in coffee based agro forestry system, , Master thesis in Forestry, UAS Bangalore, India, 87p.
3. POORNIKA RANI, B.J.,2009, Floristic diversity studies in coffee based agro forestry system, Master thesis in Forestry, UAS Bangalore, India,91p.
4. KISHORANAIK, B.,2010, Rainfall partitioning and its impact on coffee plantation, Master thesis in Forestry, UAS Bangalore, India,66p.
5. MARUTI GURAV.,2010, Hydrological studies in coffee based agroforestry system in Kodagu, Master thesis in Forestry, UAS Bangalore, India,70p.
6. CHETHANA. H.M 2009 Economic analysis of coffee production system for exploring the Socio-economic feasibility of geographical indications for Kodagu coffee". Master thesis in Agricultural Economics, UAS Bangalore, India 100p.
7. SHWETHA.B.A. 2011 Quantification and consumption pattern of fuelwood derived from coffee based agroforestry systems, UAS,Bangalore India Thesis to be submitted.
8. Ateeq Ahmed. 2009, Value chain analysis for coffee in Kodagu District of Karnataka. Master thesis in Agricultural Economics, UAS Bangalore, India 124p.

Students from French Institute of Pondicherry

Ph.D candidates

1. Katie DEMPS, (University of California at Davis, USA). Transmission of local ecological knowledge in South India.
2. Francisco ZORONDO, (Universitat Autonoma de Barcelona, Spain). Contribution of natural capital to the quality of life among tribal communities of South India

3. NANAYA, K.M., (Eidgenössische Technische Hochschule Zürich (ETHZ), Switzerland). Landscape level Dynamics and Ecosystem services

Affiliated PhD.

1. Dr. Virginie BOREUX. Eidgenössische Technische Hochschule Zürich (ETHZ), Switzerland. Agroforestry and Ecosystem services.
2. Caudill Amanda. Assessment of Mammal Biodiversity in Coffee-Dominated Landscapes in India and Costa Rica. PhD Thesis, University of Rhode Islands, USA (to be defended in 2012).

M.Sc Students

1. Julie ALET, AGROPARISTECH Montpellier, France. What are the possible current and future dynamics of agroforestry and agricultural landscapes in the Western Ghats (Southern India)? A case study: Kottoli, a village in Coorg.
2. Ursula TORRES MANKIEVICZ, Université Toulouse III-INRA DYNAFOR, France. Distribution of cavity-nesting birds in coffee agroforestry systems: Identifying indicators to monitor biodiversity response to G. robusta.
3. Mar GRAU SATORRAS, Universitat Autonoma de Barcelona, Spain. Ecological knowledge and use of natural resources among tribal communities in Kodagu district.
4. Jeremy VENDÉ, AgroParisTech-ENGREF, France. Responses of local actors to public conservation policies: The example of rights on trees, in the coffee agro-forest systems of the Western Ghats of India
5. Payal BAL, Pondicherry University. Elephants in the Coffee Estates.
6. Pierre DAMIEN BASCOU, Centre National d'Etudes Agronomiques des Régions Chaudes (CNEARC), France. Biodiversity in Coffee Plantations
7. Fanny CHRETIEN, Centre National d'Etudes Agronomiques des Régions chaudes (CNEARC), France. Characterization of production systems integrating coffee plantations in the Western Ghats
8. Margaux DECROIX, Centre National d'Etudes Agronomiques des Régions chaudes (CNEARC), France. Characterization of production systems integrating coffee plantations in the Western Ghats.

Internships of graduate students

1. Clémentine Vignault. Ecole Centrale de Paris, France.
   Coffee Value Chain and Geographical Indications in India
2. David Mercereau. Ecole Centrale de Paris, France.
   Coffee Value Chain and Geographical Indications in India
3. Joannés Guillemot, AgroParisTech - ENGREF, France. Carbon sequestration in coffee agroforestry systems of the Kodagu district

Students from University of Wales, Bangor

1. MAHFUZ –Local Knowledge of tree pruners about biodiversity associated with coffee agroforestry systems in Kodagu district of India
2. RAJU SHARMA –Local knowledge of the effects of climate change on water regimes within coffee agroforestry systems in the Western Ghats of India.

Annex 9: Meeting and workshops (2007-2011).

Date	Venue	Event	No. of participants
5/8/2007	College of forestry,Ponnampet	Interaction between Biodivalloc and CAFNET team	30
1/16/2008	College of forestry,	Workshop on ecosystem services of landscapes of Kodagu	59
7/2/2008	College of forestry,ponnampet	Talk on overview of forest conservation in Nepal	47
7/15/2008	College of forestry,ponnampet	Participatory forest management in Bangladesh	47
7/26/2008	College of forestry,ponnampet	Talk on how much is an ecosystem worth	14
8/2/2008	College of forestry,ponnampet	Talk on evaluation of ecosystem services	14
8/11/2008	College of forestry,ponnampet	Workshop on advance training in AKT	11
9/9/2008	College of forestry,ponnampet	Interaction with Mr. Colson from EU Monitoring Programme	23
10/27/2008	College of forestry,ponnampet	2nd international workshop- CAFNET project	51
10/28/2008	College of forestry,ponnampet	2nd international workshop- CAFNET project	53
10/30/2008	College of forestry,ponnampet	2nd international workshop- CAFNET project	53
10/31/2008	College of forestry,ponnampet	2nd international workshop- CAFNET project	58
11/23/2008	College of forestry,ponnampet	Talk by Dr. Thomas Husband from University of Rhode Island, USA	89
2/22/2009	Pollibetta	Conference on mutistake holder approach to sustainable coffee production and marketing	42
9/16/2009	CRSS, Chettali	Workshop on identification best management practices in coffee	20

Date	Venue	Event	No. of participants
10/10/2009	Hotel SERAI, Chikkamagaloor	CAFNET at International coffee festival - An extension	68
11/13/2009	Hotel ATRIA, Bangalore	CAFNET at KPA and UPASI coffee conference	
4/27/2010	College of forestry,ponnampet	Workshop and training programme on ecocertification on coffe in colloboration with EEU Ponnampet	26
6/7/2010	College of forestry,ponnampet	Talk by Dr. Thomas Husband from University of Rhode Island, USA	30
7/6/2009	College of forestry,ponnampet	Workshop on bee pollination in coffee plantation of Kodagu	37
7/8/2010	College of forestry,ponnampet	Talk on effect of fragmentation on genetic structure by Shasha Ismail ETH, Switzerland	11
8/16/2010	Poolemad Temple hall, Begoor	Farmer interaction on ecocertification in coffee in association with JCI,Ponnampet	19
12/3/2010	College of forestry	CAFNET at Krishi Mela at college of forestry , Ponnampet	
12/3/2010	College of forestry	All farmer group interaction meet on certification	15
12/9/2010	Press club at Madikeri	Press meet at Madikeri	
12/10/2010	Mudigere	Framer interaction meet on ecocertification organised by IIPM Bangalore and CBI Mudigere	22
12/22/2010	Rotary hall, Madikeri	Inteeraction meet with Rotarians onm Ecocertification	18

Annex 10: List of outputs produced by CAFNET Team in India

Books produced

1. Mohana, G.S., Somanna Chittiappa, Sinclair, F.L., Kushalappa, C.G., Raghuramulu, Y. and Vaast, P., 2011, Essence of Farmers Knowledge on Coffee Agroforestry Systems in Kodagu, CAFENT project, Forestry College, Ponnampet-571 216, Karnataka, India. 32 pp.
2. Poornika Rani, B.J., Sathish, B.N., Mohana, G.S., Somanna Chittiappa and C.G. Kushalappa, 2011, Field Guide -*Trees of Coffee Agroforestry Systems in Kodagu,* CAFNET project, Forestry College, Ponnampet- 571 216, Karnataka, India 260 pp.

Handouts for farmers

1. Cafnet brochure: Coffee Based Agroforestry in Kodagu, Western Ghats of India- *Need for conservation to sustain livelihoods. 2011*
2. Carbon Sequestration in Coffee Agroforestry Systems of Kodagu, Western Ghats of India. 2011.
3. Elephants Also Like Coffee: Trends and Drivers of Human Conflict In Coffee Agroforestry Landscapes of Kodagu, Western Ghats of India.2011
4. Coffee Quality in Coffee Agroforestry Systems of Kodagu, Western Ghats of India. 2011
5. Coffee quality analysis by Coffee Lab (Parts 1, 2, 3 & 4). 2009
6. Changes in rainfall pattern over the last decades in the coffee agroforestry landscape of Kodagu, South Western India. 2011
7. Biodiversity Assessment of the Coffee Based Agroforestry System of Kodagu, Western Ghats of India. Vegetation cover and bird communities. 2011.
8. Overview of the Indian Coffee Value Chain. 2011.
9. Water dynamics of coffee agroforestry systems in Kodagu district, Southwestern India. 2011.
10. Soil analysis and fertilizer recommendation to target farms. 2010.
11. Survey of tree diversity in target farms. 2010.
12. Survey of bird diversity in target farms. 2010.
13. Economical analysis of target farms. 2010.
14. Coffee quality analysis of target farms. 2010.
15. CAFNET Farmer Information Checklist of trees in the Kavery Watershed
16. Cafnet-India Mammal Diversity Summary
17. Readme CAFNET INDIA Tree diversity database
18. Readme CAFNET INDIA Sampling Protocol File
19. Readme CAFNET INDIA Sampling Strategy File

Publications and outputs based on CAFNET research and data, by team IFP (French Institute of Pondicherry):

PEER-REVIEWED ARTICLES

1. Nath, CD, Pélissier, R, Ramesh, BR, Garcia, C, (published online: 21 April 2011). Promoting native trees in shade coffee plantations of southern India: Comparison of growth rates with the exotic *Grevillea robusta*. Agroforestry Systems DOI 10.1007/s10457-011-9401 http://www.springerlink.com/content/hw10gp5518467536/
2. Bal, P, Nath, CD, Nanaya, KM, Kushalappa, CG, Garcia, C, 2011. Elephants also like coffee: Trends and drivers of human–elephant conflicts in coffee agroforestry landscapes of Kodagu, Western Ghats, India. Environmental Management, 47: 789-801. http://www.springerlink.com/content/w8rr41u559326120/
3. Nath, CD, Pélissier, R, Garcia, C, 2010. Comparative efficiency and accuracy of variable area transects versus square plots for sampling tree diversity and density. Agroforestry Systems, 79: 223–236. http://www.springerlink.com/content/7887357u63np6703/
4. Garcia, CA, Bhagwat, SA, Ghazoul, J, Nath, CD, Nanaya, KM, Kushalappa, CG, Raghuramulu, Y, Nasi, R, Vaast, P, 2010. Biodiversity conservation in agricultural landscapes: challenges and opportunities of coffee agroforests in the Western Ghats, India. Conservation Biology, 24(2): 479 – 488. http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2009.01386.x/full
5. Marie-Vivien, D., C. A. Garcia, B. Moppert, C. G. Kushalappa, P. Vaast. 2009. Marques, indications géographiques et certifications environnementales : Trois stratégies de valorisation commerciale et leurs liens avec la conservation de la biodiversité dans les ghâts occidentaux (inde). Autrepart 50.
6. Ghazoul, J. ;Garcia, C. & Kushalappa C.G. , 2009. Landscape labelling: A concept for next-generation payment for ecosystem service schemes. *Forest Ecology and Management* [online] doi:10.1016/j.foreco.2009.01.038.
7. Garcia, C., Marie-Vivien, D., Kushalappa, C.G., Chengappa, P.G., Nanaya K.M. 2007. Geographical Indications and Biodiversity in the Western Ghats, India. Can Labeling Benefit Producers and the Environment in a Mountain Agroforestry Landscape? Mountain Research and Development, 27(3): 206-210. http://www.bioone.org/doi/pdf/10.1659/mrd.0922

REPORTS

1. Alet, J. 2011. What are the possible current and future dynamics of agroforestry and agricultural landscapes in the Western Ghats (Southern India)? A case study: Kottoli, a village in Coorg. AgroParisTech-ENGREF, Montpellier.

2. Rao, V. 2011. *Impact of* Grevillea robusta *composition on bird diversity in coffee plantations in Cauvery Watershed Area of Coorg district*. French Institute of Pondicherry, Pondicherry.
3. Torres U., 2010. *Les oiseaux cavicoles: indicateurs de l'état des sysèmes agroforestiers à base de café dans les Ghats Occidentaux, Inde*. Université Paul Sabatier, Toulouse III.
4. Bal P, Nath CD, Garcia C, 2008. Drivers of human elephant interactions in coffee agro-forestry landscapes in Kodagu (Western Ghats), India. French Institute of Pondicherry, Pondicherry. http://www.ifpindia.org/Managing-Biodiversity-in-Mountain-Landscapes.html
5. Mercereau D & Vignault C., 2008. *Coffee value chain and Geographical Indications in India. Origin, reputation and marketing of Indian coffees*. CIRAD, Montpellier.
6. Decroix M. & Chretien F., 2007. Agriculture et Biodiversité. Caractérisation des systèmes agroforestiers à base de café. Institut des Régions Chaudes, Montpellier. http://www.ifpindia.org/Managing-Biodiversity-in-Mountain-Landscapes.html

CONFERENCE PRESENTATIONS

1. Nath CD, De Franceschi, D, Boura, A, Pélissier, R, 2011. Tree age estimation for tropical tree species by direct and indirect methods. Oral presentation at the Annual Symposium of the British Ecological Society, Cambridge, UK, 28-30 March 2011. http://abstracts.britishecologicalsociety.org/exports/18-bulletin.html
2. Nanaya Konerira. 2010. Linking management, ecosystem services and landscape patterns in a coffee agroforestry landscape. Talk presented in the Student Conference on Conservation Science (SCCS) 16-18 June 2010 – Bangalore India. http://www.sccs-bng.org/?page_id=4
3. Claude Garcia, Jeremy Vendé, Cheryl D. Nath, Konenrira M. Nanaya, Lucie Cheynier, C. G. Kushalappa, Philippe Vaast and Christophe le Page. 2010. Public Policies, Coping Strategies and Biodiversity: Integrating Biodiversity Conservation in a Production Landscape of the Western Ghats, India. Oral presentation at Association of American Geographers, Annual meeting 14-18 April, 2010, Washington, DC*, USA.* http://meridian.aag.org/callforpapers/program/AbstractDetail.cfm?AbstractID=27727
4. P Vaast, K.M Nanaya, A Devakumar, CG Kushalappa, C Garcia. 2009 Long-term changes in tree cover and landscape dynamics affect rainfall patterns in the coffee-agroforestry district of Kodagu, India. Oral presentation at 2nd World Congress of Agroforestry, Nairobi, Kenya, 23-28 August, 2009. http://www.worldagroforestry.org/wca2009/reports/docs/Book%20of%20Abstracts-Final%20with%20Index%20new.pdf. P. 176
5. Garcia, CA, Nath, C, Nanaya, KM, Kushalappa, CG, Vaast, P. Patterns of tree biodiversity in coffee agroforestry systems of the Kodagu district, Western Ghats,

India. Oral presentation at 2nd World Congress of Agroforestry, Nairobi, Kenya, 23-28 August, 2009. http://www.worldagroforestry.org/wca2009/reports/docs/Book%20of%20Abstracts-Final%20with%20Index%20new.pdf. p. 42

6. Bal, P, Nath, C, Kushalappa, CG, Garcia, CA. The wicked elephant of the east: Coping with Human Elephant conflicts in coffee agro-forestry landscapes in Kodagu (India). Oral presentation at 2nd World Congress of Agroforestry, Nairobi, Kenya, 23-28 August, 2009. http://www.worldagroforestry.org/wca2009/reports/docs/Book%20of%20Abstracts-Final%20with%20Index%20new.pdf. p. 61
7. Nath, C, Garcia C, Kushalappa, CG, Vaast, P. Influence of economics and public policies on native species conservation in coffee agroforestry systems of Kodagu (India). Poster presentation at 2nd World Congress of Agroforestry, Nairobi, Kenya, 23-28 August, 2009. http://www.worldagroforestry.org/wca2009/reports/docs/Book%20of%20Abstracts-Final%20with%20Index%20new.pdf. p. 459
8. Nanaya, K.M., C Garcia, P Vaast, Kushalappa, C.G. and C Nath. 2009. Methodological Framework for integration of multidisciplinary data into coffee agroforestry systems: example of the CAFNET project. Poster presentation at 2nd World Congress of Agroforestry, Nairobi, Kenya, 23-28 August, 2009. http://www.worldagroforestry.org/wca2009/reports/docs/Book%20of%20Abstracts-Final%20with%20Index%20new.pdf. p. 42

Publications of UAS Bangalore

PEER-REVIEWED ARTICLES

1. A.N. Chethanaa , N. Nagaraja, P.G. Chengappa and C.P. Gracy 2010 Geographical Indications for Kodagu Coffee – A Socio-economic Feasibility Analysis. *Agricultural Economics Research Review.* Vol. 23 January-June 2010. pp 97-103.

CONFERENCE PRESENTATIONS

1. Satish,B.N. C.G., Kushalappa and K.M. Nanaya. Impact of the canopy cover on the productivity and quality of shade grown coffee in Kodagu district, South India. "Second International Symposium on Multi-Strata Agro forestry Systems with Perennial Crops" held from 17 - 22 September 2007 at CATIE.
2. Satish,B.N. Kushalappa.C.G.and Claude Garcia. Land tenure systems: A key to conserve tree diversity in multistoryed Coffee Agroforests of Kodagu, Central Western Ghats, India. By, "Second International Symposium on Multi-Strata Agro forestry Systems with Perennial Crops" held from 17 - 22 September 2007 at CATIE.
3. Kushalappa.C.G. Ecological and Economic analysis of Coffee Agroforestry Systems: Case study from Central Western Ghats, India. Oral paper presented in 2nd world

congress of Agro forestry- The future of global land use, held during 23 to 27th August, 2009, Nairobi, Kenya.

4. A.N. Chethana, H.N.Ragavendra, Dr.N.Nagaraj Dr.C.P.Gracy Dr. Philippe Vaast, Dr.C.Garcia & Dr.D.Maie-Vivien(Poster) Shade trees and income diversification from coffee agro forestry farms - Field evidences from Kodagu district, South India. Abstract published in proceedings of the 2nd world congress of Agro forestry- The future of global land use, held during 23 to 27th August, 2009, Nairobi, Kenya;
5. C.Raveesh, Dr.J.Bagyaraj, Dr.Philippe Vaast. Belowground Microbial Diversity as Influenced by Coffee Agroforestry Ecosystems in Kodagu, Western India. (Poster) Abstract published in proceedings of the 2nd world congress of Agro forestry- The future of global land use, held during 23 to 27th August, 2009, Nairobi, Kenya.
6. Poornikarani,B.J., Dr.Kushalappa,C.G, Dr.Sinclair,F.L, Dr. Vaast, P, Mr. Jadyegowda, and Mr. Ramesh,M.N. Effect of tree composition on epiphytic species abundance in coffee agroforestry systems of Kodagu, Abstract published in proceedings of the 2nd world congress of Agro forestry- The future of global land use, held during 23 to 27th August, 2009, Nairobi, Kenya.
7. Mohana, G.S., Kushalappa, C.G., Sinclair, F. and Vaast, P., Relevance of Local Knowledge in Conserving Biodiversity and Sustaining Production of Coffee Agro-forestry Systems in Coorg district, Western Ghats of India. Abstract published in proceedings of the 2nd world congress of Agro forestry- The future of global land use, held during 23 to 27th August, 2009, Nairobi, Kenya.
8. BJ Poornika Rani, S Chittiappa, M Manjunath, K Kamal, G. S. Mohana, CG Kushalappa,F Sinclair and P Vaast,Local knowledge on floristic diversity of coffee agroforestry systems in Kodagu, Western India: implications for conservation, Abstract published in proceedings of the 2nd world congress of Agro forestry- The future of global land use, held during 23 to 27th August, 2009, Nairobi, Kenya
9. Harish T.T., Mohana, G.S. Jadegouda, Karumbaiah B.A., Kushalappa C.G., Sinclair, F., and Vaast, P**,** Faunal diversity in Coffee agro forestry systems in Kodagu: Implications of local knowledge in conservation. Abstract published in proceedings of the 2nd world congress of Agro forestry- The future of global land use, held during 23 to 27th August, 2009, Nairobi, Kenya.
10. Karun Chinnappa, N. Mohana, G.S., CG Kushalappa, F Sinclair and P Vaast, By-products from coffee agroforestry systems: does local knowledge of stakeholders help in conservation of biodiversity? Abstract published in proceedings of the 2nd world congress of Agro forestry- The future of global land use, held during 23 to 27th August, 2009, Nairobi, Kenya.
11. Kushalappa, C.G. , Vaast P., Raghuramulu Y., Garcia C., Sinclair F. and Somanna C. Coffee Based Agroforestry in Kodagu, Western Ghats, India- Need for conservation to sustain livelihoods. Oral presentation in 23rd International Conference on Coffee Science Bali (Indonesia), 3th – 8th October 2010.

12. Caudill SA., Husband TP., and Vaast P A. Coffee-Forest Matrix: Conservation Strategy for Sustainable Agriculture. Conference on International Sustainable Development and Research, Columbia University, USA, May 2011.

Presentations in national workshops and forums:

1. Mohana, G.S., 2011, Local knowledge Documentation and Agroecological Knoweldge Toolkit (AKT) in Coffee Agroforestry Systems of Kodagu. Presented during Final CAFNET Mela, Kodava Samaja, Ponnampet. April 15-16
2. Mohana, G.S., 2008, Preliminary validation of local knowledge in coffee agro forestry systems in Coorg through AKT methodology" presented in the Second International Workshop of CAFNET- Connecting Environmental Services and Market values of Coffee Agroforestry held at College of Forestry, Ponnampet, Coorg district, India during 27th to 31st October, 2008.
3. Mohana, G.S., 2008, 'Advances in Agro-ecological knowledge base of coffee agro forestry systems in Coorg' talk delivered at Kodava Samaja Napoklu May 13, 2008
4. Kushalappa. C.G. "Coffee Agroforestry in Kodagu, Western Ghats, India- Need for Conservation to sustain livelihoods". Scientific Conference of United Planters Association of South India (UPASI) held on 13th and 14th September 2010 at Coonor in Tamil Nadu.
5. Kushalappa.C.G. " Ecosystem Service Valuation in Coffee" in the scientific seminar of Karnataka Planters Association held on 3-11-2009 at Bangalore.
6. Kushalappa.C.G. "Biodiversity of Coffee Plantations Seminar on Coffee and Biodiversity", organized by Coffee Board as part of International Biodiversity year, on 28-12-2010 Bangalore.
7. Main results on Biodiversity Mela 2011
8. Proceedings of Cafnet Mela 2011
9. Main results on Carbon sequestration Mela 2011
10. Main results on Hydrology Mela 2011
11. Minutes of first meeting of CAFNET Mela Organizing committee 2011
12. Minutes of the meeting_29.5.2010
13. Overall achievements CAFNET project India
14. Presentation CAFNET India 2009
15. Proceed steering com 22.12.2010
16. Main results on Rainfall Mela 2011
17. Report of Cafnet workshop in Costa Rica 2007
18. Report of Cafnet workshop in Kenya 2009
19. Report of World Coffee Congress in Bali 2010

Radio Talks

1. Mohana, G.S., , Traditional Knowledge and its significance in Agriculture, All India Radio, Madikeri, Coorg district, Aired on 06-05-2011
2. Kushalappa,C.G. Cafnet Mela 2011 All India Radio, Madikeri, Coorg district, Aired on 11-4-2011

Newspapers

A total 14 press releases during the period of 2007-2011 on activities, results and recommendations of the CAFNET project in India in local and English languages.

CAFNET

Conectando y sosteniendo los servicios ambientales y de mercados para café agroforestal en Centroamérica – (Costa Rica, Guatemala y Nicaragua)

Enero 2007 – Junio 2011

Informe Final




CONTENIDO

Presentación

Las plantaciones de café tienen impactos ambientales en larga escala: por ejemplo cubren casi 1.000.000 hectáreas del istmo centroamericano, 2.000.000 hectáreas de la región este africana y 350.000 hectáreas en la India. En estas regiones el café ha sido el principal cultivo agrícola, y la fuente de ingresos de exportación durante más de 100 años. Actualmente, la producción del café sostiene aproximadamente 300.000 familias productoras en América Central, 1.200.000 en África del Este y a 180.000 en la India. Estas plantaciones de café se sitúan a menudo en los ecosistemas montañosos frágiles, muchos en las líneas divisorias de las cuencas que suministran el agua a los centros urbanos. Además, estas regiones del café son refugios para la biodiversidad del planeta y los cafés agroforestales con los árboles de cortina entremezclados entre las plantas del café son a menudo el único hábitat y las únicas coberturas arbóreas restantes dentro de estas áreas. Los cafés agroforestales son habitat dominantes para muchas aves migratorias, especialmente en América Central. También proporcionan conectividad dentro de los paisajes degradados y hacen fragmentos que incluyen áreas protegidas, y ayudan a facilitar el movimiento y a mantener la viabilidad de las poblaciones dominantes de la fauna (es decir mamíferos grandes). Así, la promoción de la diversidad de los sistemas multi-estratos de agroforestería con café beneficia los esfuerzos nacionales e internacionales de conservación. Los árboles en plantaciones de café pueden proporcionar fuentes alternativas de productos de bosque en los paisajes en gran parte deforestadas que actúan a veces como zonas tapón alrededor de áreas protegidas y de bosques nativos restantes. Hay muchas oportunidades para realzar la cobertura arbórea en las tierras de producción café y que son críticas para las funciones de protección y que extienden las funciones del bosque mientras que sostiene los medios de vida rurales. En estas tres regiones, el uso de energía rural y urbano del hogar se apoya en gran parte en los combustibles derivados de madera de árboles en café agroforestal, por lo tanto reduciendo la presión sobre el cerco de bosques naturales. Los árboles de cortina proporcionan cantidades significativas de madera, frutas y otros productos (medicinas, fibras, etc naturales), por último de valor particular para las mujeres y los niños.

El proyecto CAFNET desarrollado paralelamente en tres continentes entre 2007 y 2011. En África estuvo en Kenia, Uganda y Rwanda, en Asia se desarrollaron actividades en la India. En Centroamérica CAFNET estuvo representado en Costa Rica, Guatemala y Nicaragua. En los tres continentes los objetivos propuestos por el proyecto fueron:

Objetivos generales:

- Vincular manejo sostenible y servicios ambientales con mercados que compensan los servicios ambientales
- Contribuir el bienestar de comunidades cafetaleras que conserven los recursos naturales en 3 regiones de alta biodiversidad

Objetivos específicos:

- Promover la implementación de prácticas agroforestales sostenibles a través de guías desarrollados por comités multi-sectoriales de seguimiento, pruebas pilotos por productores experimentadores, y diseminación en comunidades prioritarias

- Calificar y valorar biodiversidad y otros servicios ambientales brindados por café agroforestal a nivel de fincas y paisajes
- Reforzar el acceso a información, contactos con sector privado, y capacidad empresarial y administrativo de organizaciones de productores.
- Vincular el manejo sostenible de café agroforestal y beneficios ambientales con reconocimiento económico para los productores por medio de mejor acceso a mercados y pagos por servicios ambientales

Para Centroamérica el CATIE coordinó el proyecto y ejecutó las acciones en colaboración con el equipo de CIRAD en Costa Rica y con las diferentes organizaciones e instituciones en cada país (Anexos 1, 2,3 y 4). En el anexo 5 se presenta una amplia lista de documentos producidos por el equipo CAFNET-Centroamérica. En el anexo 6 se resume la lista de diferentes eventos realizados durante la ejecución del proyecto. A continuación se presenta los principales resultados del proyecto que ayudaron a llenar vacíos importantes sobre el conocimiento asociado a los cafés especiales, y en particular bajo sistemas agroforestales.

1.Beneficarios finales y/o grupos colaboradores en zonas de acción del proyecto

El proyecto CAFNET se desarrollo buscando aportar de manera directa a los procesos de promoción de cafés sostenible conducido por los (as) productores (as) y sus organizaciones en las tres zonas piloto y en otras zonas de referencia y en los tres países involucrados. La información generada y los procesos de fortalecimiento de capacidades locales sobre los temas de interese estuvieron y están disponibles de manera más directa para unas 21.500 familias productoras de café en los tres países agrupadas en las distintas organizaciones vinculadas al proyecto.

En Nicaragua: participaron organizaciones como CAFENICA, COMPROCOM y CECOCAFEN que están también bajo la colaboración con CAFENICA) y la Empresa ATLANTIC-ECOM que juntos involucran a más de 10.000 Productores(as) de café en la región de influencia del proyecto.

En Costa Rica: participaron como organizaciones de productores APOT, el grupo de Cooperativas de COOCAFE y la empresa FJ Orlich-ECOM. De esta manera las organizaciones y empresas colaboradoras del proyecto están vinculadas directamente con aproximadamente 8500 productores (as) incluyendo beneficiarios en zona piloto de CAFNET y otras zonas del país.

En Guatemala: para la región de influencia directa del proyecto CAFNET las organizaciones colaboradoras, tanto las organizaciones de productores ADIPSA y Asociación Albores, como Defensores de la Naturaleza y ANACAFE actúan en un territorio que albergan unas 3.000 familias productoras de café.

Para permitir una base de experimentación y aprendizaje más sólido el proyecto concentró el desarrollo de sus diferentes componentes en zonas pilotos (ver figura 1) en cada uno de los tres países, sin embargo diferentes acciones tuvieron carácter nacional. A continuación se describe brevemente cada zona piloto.

1-Sierra de las Minas-Guatemala
2-Peñas Blancas-Nicaragua
3-Corredor Biológico Volcánica Central-Costa Rica

Fig. 1. CAFNET – ZONAS PILOTO
América Central

1.1.Sierra de la Minas (Guatemala)

La zona piloto de CAFNET correspondió en gran parte de la cuenca del Rio Hato, dentro del área de influencia de La Reserva de la Biosfera Sierra de las Minas, cubriendo un territorio de 242.642 hectáreas, de los cuales 120.000 hectáreas son zona de cobertura forestal fundamentales para la conservación y recarga hídrica. Unas 122.642 hectáreas contiene la zona de uso sostenido (de 1200 a 2300 msnm), donde se permite sistemas agroforestales con café, cardamomo y frutales, así como la zona de amortiguamiento (menor a 1200 msnm) donde se encuentra todavía el café en sistemas agroforestales, otros cultivos (entre ellos la caña, granos básicos) y la ganadería.

La cuenca del Rio Hato "tiene una extensión de 19,786 ha (46 % del municipio), tiene un rango altitudinal de 300 a 2900 msnm., factor determinante en el cultivo y la producción de café, el cual se distribuye entre los 800-1700 msnm. El cultivo de café es el más importante a nivel local puesto que influye en la economía de las familias ya que representa buenos ingresos económicos a los agricultores, sin embargo para ello hace varios años debió hacerse un cambio de cobertura vegetal de talar extensiones de área para implementar el cultivo de café, la diversidad de sombra actualmente hace que exista una alta biodiversidad en los cafetales ubicadas en la zona de amortiguamiento y uso sostenido dentro de la subcuenca del río Hato. Algo muy importante evidenciar es que la sombra de los cafetales ha permitido mejorar la conectividad de áreas dentro de la reserva, para ello facilita la movilización de especies o individuos que requiere de asocio de vegetales tales como la familia de los chipes aves que forrajean en grupos y que prefieren los bosques mixtos de pino-encino », (del Cid y Tot, 2008).

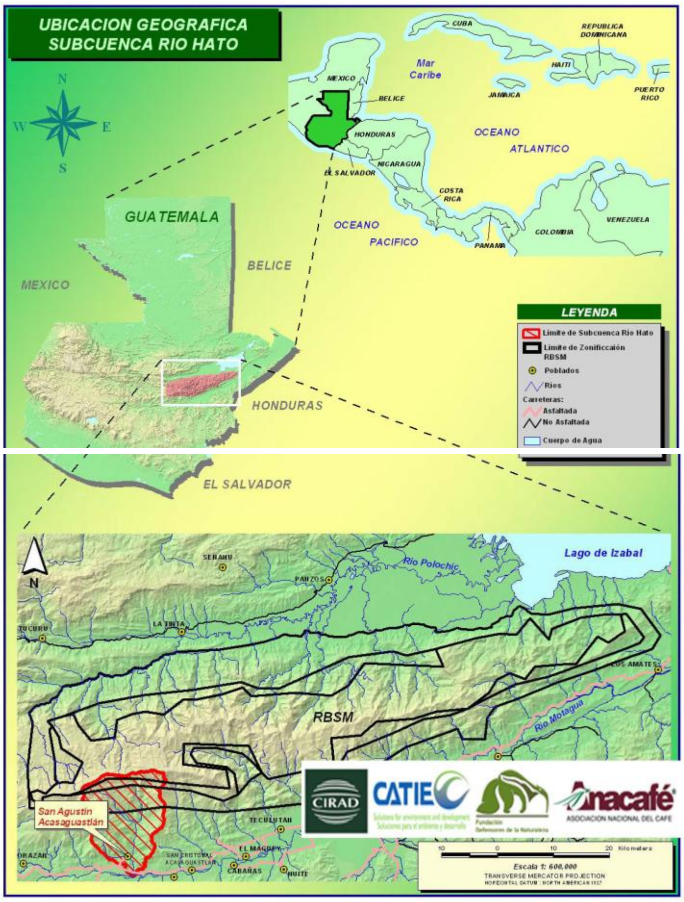


Fig. 2. Subcuenca Rio Hato, zona piloto CAFNET en la Reserva de Biosfera Sierra las Minas-Guatemala.

1.2.Peñas Blancas (Nicaragua)

En Nicaragua el comité interinstitucional conjuntamente con el equipo del proyecto seleccionó como área piloto las zonas cafetaleras del macizo de Peñas Blancas en el norte del país. “El macizo de Peñas Blancas es una de las áreas naturales más importantes del departamento de Jinotega. De las seis áreas protegidas que conforman la reserva de Biosfera Bosawas, cinco son Reservas Naturales entre ellas se encuentra el Macizo de Peñas Blancas con una superficie de 11,308 Has. Es parte del 6 % de las tierras altas de Nicaragua, fue declarada Reserva natural en Noviembre de 1991, es importante por sus especies endémicas pero sobre todo por la existencia de quebradas y ríos. Se encuentra ubicada al sur oeste de la reserva de Biosfera Bosawas, entre las coordenadas 13º13´27˝ latitud norte y 85º35´25˝ longitud oeste y su punto más alto alanza 1,745 msnm.”, (Jerez, 2008).

El territorio ocupado por el macizo es de 115,54 Km² distribuidos en los municipios del Cuá, Rancho Grande y La Dalia. “En la zona de amortiguamiento y parte de la zona núcleo habitan aproximadamente unas 60,500 personas quienes en su mayoría son mestizos ubicados principalmente en las zonas de amortiguamiento de la reserva en los municipios de El Cuá, San José de Bocay, Rancho Grande y la Dalia. La población rural y urbana de la zona de amortiguamiento en los municipios oscila entre el 15% urbana y 85% rural” (Flores y Alvarado, citados por Jerez, 2008). Un elemento importante es que dentro de las áreas protegidas del macizo de Peñas Blancas (fig. 3) se encuentra 1944,5 ha de café (1610,59 en sistemas agroforestales y 333,91 en pleno sol) siendo el valor más destacado en relación a otras áreas protegidas que tiene cafetales en sus áreas de influencia, (MAGFOR citado Jerez, 2008).

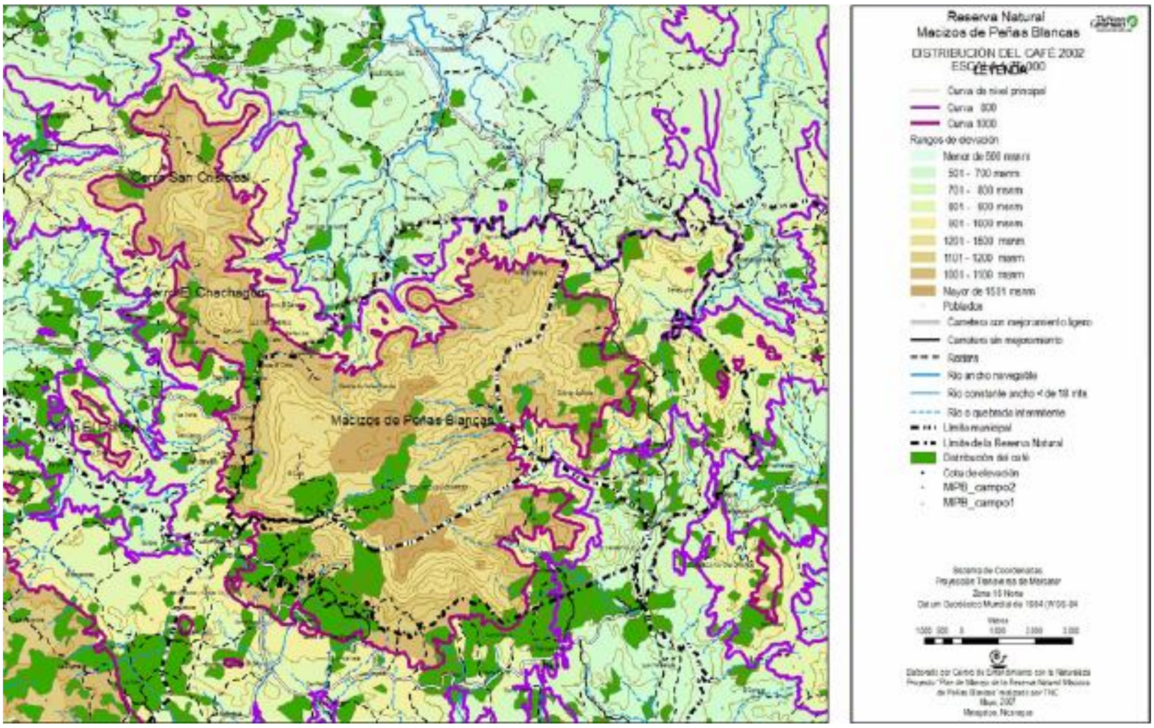


Fig. 3. Reserva Natural Macizo de Peñas Blancas, zona piloto CAFNET. (verde oscuro distribución de cafetales)- Nicaragua. (Fuente: MARENA-CCDMPB-CALMECATL-TNC, 2007)

1.3.Turrialba (Costa Rica)

En el caso de Costa Rica la zona piloto del proyecto fue El Corredor Biológico Volcánica Central – Talamanca, ocupando un 23,1% de la provincia de Cartago con un área de 72.082 hectáreas. “El CBVCT comprende el Área de Conservación de la Cordillera Volcánica Central (ACCVC) y tiene un rango altitudinal que va desde los 339 msnm en el distrito de Peralta hasta los 3340 msnm en el Volcán Turrialba”. El CBVCT coincide con importante territorio del Área de Conservación de la Cordillera Volcánica Central (ACCVC) con rango altitudinal de 339 msnm a 3340 msnm, (Canet 2003, citada por Florian, 2008). Diferentes aspectos expresan la importancia ambiental, social y económica de la región. Las cuencas hidrográficas de la región son responsables por importantes proyectos hidroeléctricos del país, el paisaje guarda una biodiversidad de fundamental importancia.

Los 15 distritos que integran el CBVCT tienen una población de 91.696 habitantes (http://es.wikipedia.org/wiki/Lista_de_Distritos_de_la_Provincia_de_Cartago (8-7-2011) y Florian, 2008).

Cuanto al uso de la tierra el 40% del territorio está bajo bosques. “La ganadería es el uso de suelo más dominante dentro del área, el cual corresponde a un 28% del área seguido por las plantaciones de café (14.1% del áreas). La mayor parte de la producción cafetalera se concentra en los distritos de Turrialba, Santa Rosa (la finca Aquires), Santa Teresita (Finca La Zayda), Pavones, La Suiza, Tuis y Cachí. La producción de caña ocupa un 5.8 % del área y predominan entre la parte centro y sur del corredor, específicamente en los distritos de Juan Viñas, Turrialba, Tayutic, Pejivalle y Tucurrique, en donde se ubican varias industrias azucareras como parte integral de esta actividad. Por otra parte, en el área de estudio también se puede observar otras categorías de uso como los son cultivos perennes, sistemas agroforestales, cultivos anuales, plantaciones forestales, cuerpos de agua y asentamientos humanos”, (Florian, 2008). La distribución territorial de los diferentes usos de la tierra puede ser visualizada en la figura 4.

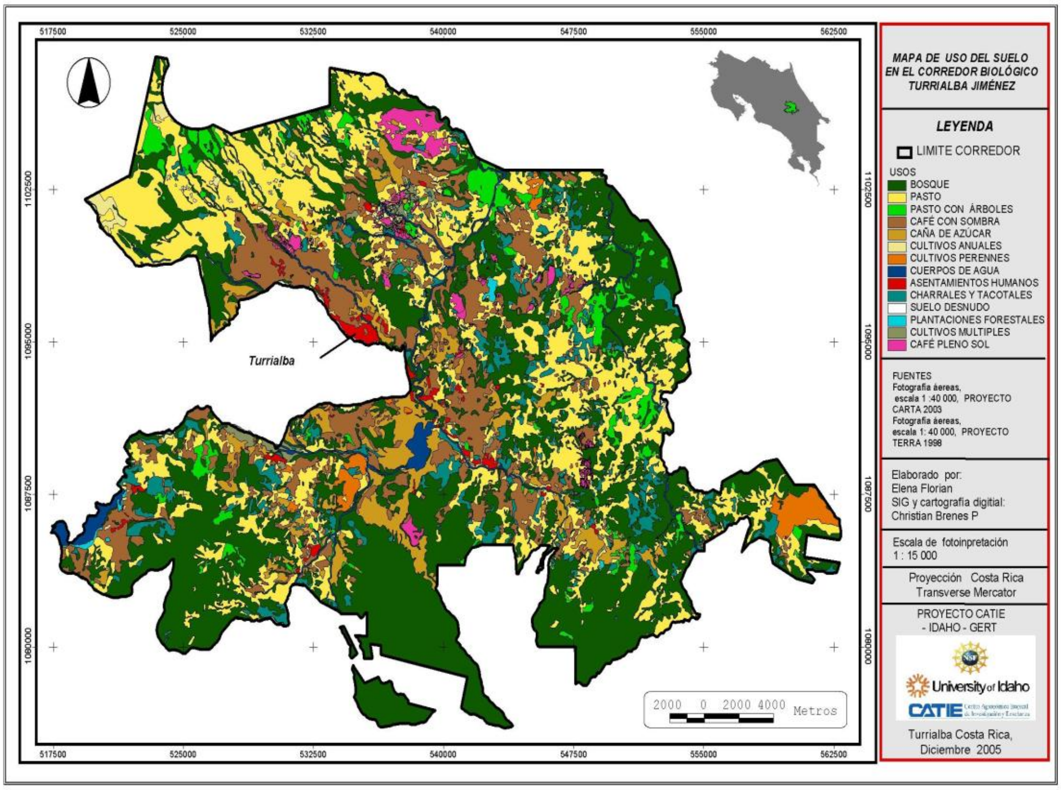


Fig. 4. Uso del suelo Corredor Biológico Volcánica Central Talamanca, zona piloto CAFNET, Costa Rica (Fuente: Florian, 2008)

2.Establecimiento de comités de seguimiento multi-institucional en zonas de acción.

Los miembros de los comités de colaboración se enumeran en los anexos 2,3 y 4, y los integraron organizaciones de productores, empresas de café, organizaciones de representación del sector cafetalero, organizaciones gubernamentales y no gubernamentales, agencias certificadoras y programas universitarios. Un trabajo importante desarrollado por los comités en cada país fue la selección de sitios específicos para la realización de estudios y procesos promovidos por CAFNET. Entre las acciones desarrolladas en zonas piloto estuvieron:

i. Monitoreo de la biodiversidad en las fincas de café;
ii. Validación de prácticas agroforestales de gestión;
iii. Supervisión de los servicios ambientales;
iv. Evaluación de costos y beneficios de los esquemas de certificación
V. Evaluación de las leyes ambientales locales;
vi. Sistemas de información geográfica para la gestión de la tierra;

Tiempo invertido en el establecimiento inicial de comités de colaboración en los países

Concepto	Costa Rica	Nicaragua	Guatemala
Número de reuniones	6	3	5
Equipo de investigadores	1mes y 7 días	6 días	2

Equipo técnico	4 días	9 días	10
Total	1mes + 17 días	18 días	17 días

3.Documentación de conocimientos locales sobre sistemas agroforestales tradicionales y valoración de los árboles nativos.

Gabriela Soto
Carlos Cerdan
Bruno Rapidel

Principales resultados:

1. Productores en las zonas piloto del proyecto con mayor reconocimiento sobre sus propios conocimientos en el tema de manejo de cafetales y la provisión de servicios ecosistémicos. Esto se logró a través de visitas a cada productor, talleres de devolución de su propio conocimiento, etc;

2. Técnicos en las regiones, incluyendo Fondo de Agua (Guatemala), Universidad del Valle (Guatemala), FondeAgro (Nicaragua), Nitlapan, (Nicaragua), Universidad Nacional Agraria (Nicaragua), Universidad de Costa Rica (sede Turrialba) con un mayor conocimiento sobre la herramienta para sistematizar el conocimiento local utilizada (AKT) y sus potenciales del uso;

3. Técnicos conocen mejor las percepciones de los productores acerca de los servicios ecosistémicos que proveen sus cafetales;

4. Técnicos utilizan terminología más precisa (arboles frescos y calientes) para trabajar con los productores de sus regiones;

5. Se definieron vacíos de información, sobre percepciones de los productores en campo, que no han sido observado por la ciencia, y que deben ser respaldados con investigación (ejemplo el rol de los laureles en la polinización del café y la sobrevivencia de las abejas en la región);

6. Publicaciones: 5 publicaciones científicas (1 artículo por país, 1 artículo comparativo de las 3 regiones, 1 artículo comparando orgánico y convencional en Costa Rica), y 4 manuscritos (en español e inglés) donde con lenguaje sencillo se presentan los principales resultados y como utilizar el programa AKT (1 por país más 1 de los resultados generales de los 3 paises). Así como 3 bases de datos de conocimiento local y servicios ecosistémicos en cafetales;

7. Presentaciones científicas: Poster en el 2º Simposio Internacional de Agroforesteria Multistrata con Cultivos Perennes y presentación oral en el 2º Congreso Mundial de Agroforesteria.

Se encontró que los productores de los 3 países utilizan clasificaciones locales de los árboles y la vegetación espontanea, conectando los atributos de los árboles con los servicios ecosistémicos. Estas clasificaciones son la forma en la cual los productores entienden y regulan los servicios ambientales dentro de sus fincas. En el caso específico de Nicaragua fue interesante encontrar cómo la asistencia técnica y las capacitaciones han impactado la comprensión de los productores sobre los procesos agroecológicos en sus fincas.

Algunos de los servicios priorizados por los productores son la conservación de agua y la formación de los suelos. En las guías por país se muestra detalladamente el conocimiento de los productores sobre la relación de las especies de árboles en la estabilidad del suelo, conservación, formación, mantenimiento de la fertilidad y disminución de la erosión de los suelos. Así como el impacto de las especies de árboles en la estabilidad del suelo y en las fuentes de agua, humedad de las plantaciones y su rol con la regulación del clima. La abundancia de ciertas especies de árboles no dependió únicamente del número de "servicios" que un árbol podía ofrecer; sino también de la ponderación de los servicios según los productores.

El conocimiento de los productores varía de acuerdo a las condiciones agroecológicas donde estén ubicadas sus fincas, por ejemplo, para el área de Guatemala, donde hay grandes diferencias entre la altitud dentro del municipio de San Miguel de Acasaguastlan, se encontraron diferencias en las especies en todo el paisaje cafetalero y las prácticas agrícolas.

Lecciones aprendidas de conocimiento local

1. *En los tres países estudiados (Nicaragua, Costa Rica y Guatemala), los productores tienen un amplio y profundo conocimiento de los servicios ecosistémicos locales que proveen sus cafetales, relacionados con suelo y aguas: conservación del suelo, mantenimiento de la fertilidad de suelo, protección de las fuentes de agua, regulación del microclima, regulación de enfermedades y plagas, interacción con la producción cafetalera.*
2. *Existe un menor conocimiento en temas de importancia científica, por ejemplo lo que se refiere a cambio climático. Los productores han percibido cambios climáticos pero no tienen claridad en las razones, poco conocen sobre el rol de los SAFC en la captura de carbono y no tienen claro las consecuencias puede haber en la producción de café. Sin embargo, algunos productores han cambiado la regulación de sombra debido a cambios climáticos.*

3. *Los productores transmiten conocimientos resultado de sus observaciones y también lo que han adquirido a través de capacitaciones. Muchas de las observaciones adquiridas a través de capacitaciones son procesos que ellos no pueden observar directamente en el campo (fijación biológica de nitrógeno, solubilización del fósforo de la materia orgánica, etc.).*
4. *Los productores conocen los rasgos funcionales o atributos de los árboles (tamaño de la hoja, profundidad de raíces, etc.) que les permiten proveer mayores servicios ecosistémicos de agua y suelo, con una clara vinculación causa efecto.*
5. *El servicio de conservación de biodiversidad es mencionado únicamente en relación con especies que los productores observan, y particularmente las aves. La vinculación se limita a la provisión de alimento (árboles frutales favorecen biodiversidad, por ejemplo).*
6. *Estas características funcionales que permiten a los productores determinar el rol de los árboles en la provisión de servicios de suelo y agua, los ha llevado a clasificarlos como árboles "frescos" y árboles "calientes". Esta terminología y clasificación fue observada por los productores en los tres países estudiados.*
7. *Una mejor comprensión de la terminología de árboles frescos y calientes, dado que es conocida por los productores de toda la región, debe ser profundizada y utilizada por los técnicos que trabajan en extensión agrícola, para garantizar una mejor comunicación con los productores.*
8. *En general la mayoría de los productores, aunque conocen el rol de los árboles en la provisión de servicios ecosistémicos, al momento del manejo le dan prioridad a la productividad del café sobre otros servicios.*
9. *Para fomentar la provisión de servicios ecosistémicos del cafetal se debe trabajar en investigación que promueva una mayor provisión sin disminuir la productividad del café. La selección de las combinaciones de árboles y su manejo debe de fundamentarse en los conocimientos de los productores, para los cuales la sistematización realizadas en este proyecto constituye una buena base. Sin embargo, se tendrá que adaptar a cada región de trabajo, ya que la validez de este conocimiento es local.*

Tiempo invertido en el componente Conocimiento local

Concepto	**Costa Rica**	**Nicaragua**	**Guatemala**
Estudiante de doctorado (dias)	90	70	50
Equipo CATIE (días)	20	5	5
Equipo Bangor (dias)	5		
Equipo CIRAD (días)	7		
Total (días)	**122**	**75**	**55**

4.Conservación de la biodiversidad en los sistemas agroforestales de café

Introducción:

Los sistemas agroforestales de café han despertado un gran interés como herramientas de conservación ya que dependen de un cultivo perenne tolerante a la sombra. Asimismo, los compradores de café de los Estados Unidos y Europa muestran más interés por problemas como la deforestación, la justicia social y la sostenibilidad ambiental. Como tal, el café, quizá a mayor escala que la mayoría de los cultivos, tiene una considerable cantidad de certificaciones ambientales. Las más sobresalientes son la certificación *Rainforest Alliance*, *Smithsonian Bird Friendly* y *C.A.F.E Practices* de Starbucks.

En el proyecto CAFNET procuramos evaluar la contribución de estas certificaciones en la conservación de la biodiversidad al concentrarnos en dos grupos taxonómicos: aves y mamíferos. Realizamos dos estudios de mamíferos cuyos resultados se han presentado en conferencias internacionales y ya están listos para su publicación. Hemos realizado un estudio de monitoreo de aves a largo plazo que constituye, hasta donde sabemos, la iniciativa de monitoreo de mayor duración en los paisajes agrícolas centroamericanos (web.catie.ac.cr/pma). El estudio de aves se ha presentado en diversas conferencias internacionales y nacionales, ha sido aprobado para su publicación en una revista científica latinoamericana, y está siendo preparado para ser publicado en una revista científica internacional. Los estudios de mamíferos y aves continuarán incluso después de que finalice CAFNET.

Vivir en el límite: los sistemas agroforestales de café como amortiguadores de bosque para mamíferos pequeños y medianos

Participantes en la investigación: Fabrice DeClerck, Mario J. Gómez, Natalia Estrada Carmona, David Abedon, y Thomas Husband

A pesar del gran enfoque en el aporte del café de sombra a la conservación de la biodiversidad, la mayor parte del mismo se centra en la conservación de aves, y son muy escasos los enfoques en conservación de mamíferos. En una revisión de literatura realizada en la red científica ISI, con base en las palabras clave "café y biodiversidad", encontramos 83 artículos con información original a nivel de campo. La mayoría de ellos hace referencia a la conservación de aves en los sistemas cafetaleros. Por el contrario, sobre la biodiversidad de mamíferos en las plantaciones de café, sólo encontramos cinco documentos publicados con información original y tres publicaciones adicionales que hacen referencia exclusivamente a los monos aulladores (*Alouatta palliata*). A pesar de que el café se cultiva en Asia, África, América del Sur y Mesoamérica, es sorprendente que todos los estudios publicados sobre biodiversidad de mamíferos provienen de México (2 estudios), Costa Rica (2 estudios) y de las Ghats occidentales de la India (1 estudio). La falta de datos publicados sobre la importancia de la conservación de fincas cafetaleras es sorprendente, en particular, debido a la gran atención que se da al café como cultivo ecoamigable.

Con el propósito de aminorar este vacío, realizamos un estudio en dos plantaciones cafetaleras ubicadas en el Valle de Turrialba en Costa Rica. El objetivo principal del estudio fue probar si las plantaciones cafetaleras ofrecen un hábitat apropiado para la biodiversidad de mamíferos, y cómo se le compara con el hábitat del bosque circundante. Las dos fincas donde se llevó a cabo el estudio (Aquiares y Machina Vieja) se consideran grandes de acuerdo con los estándares locales, pero lo más importante es que colindan con extensas zonas forestales. Esto nos permitió probar el valor de conservación del café por sí solo y observar si en los sistemas agroforestales de café existían algunos efectos significativos de amortiguamiento. Nuestro protocolo de muestreo consistió en tres transectos (o fajas) de 400 metros lineales por finca, con 100 metros del transecto ubicado en la plantación de café, seguidos de 300 metros en el bosque adyacente. Colocamos dos trampas Sherman cada 10 metros (82 trampas por transecto) y una trampa "tomahawk" más grande cada 100 metros, para un total de 5 por transecto. Además, instalamos una trampa cámara en los últimos 100 metros de la parte boscosa del transecto. La Figura 1 muestra la ubicación de los transectos en Aquiares (izquierda) y en Machina Vieja (derecha).

Ambas fincas poseen una cubierta de árboles relativamente baja e incorporada al café. En Aquiares, que cuenta con la certificación *Rainforest Alliance* y *Starbucks*, la sombra la dan, en particular, árboles de *Erythrinia poeppigiana* y *Cordia alliodora* sin podar. Por el contrario, en Machina Vieja, la sombra la dan, principalmente, *E. poeppigiana* podados y plantas de banano con fines comerciales.

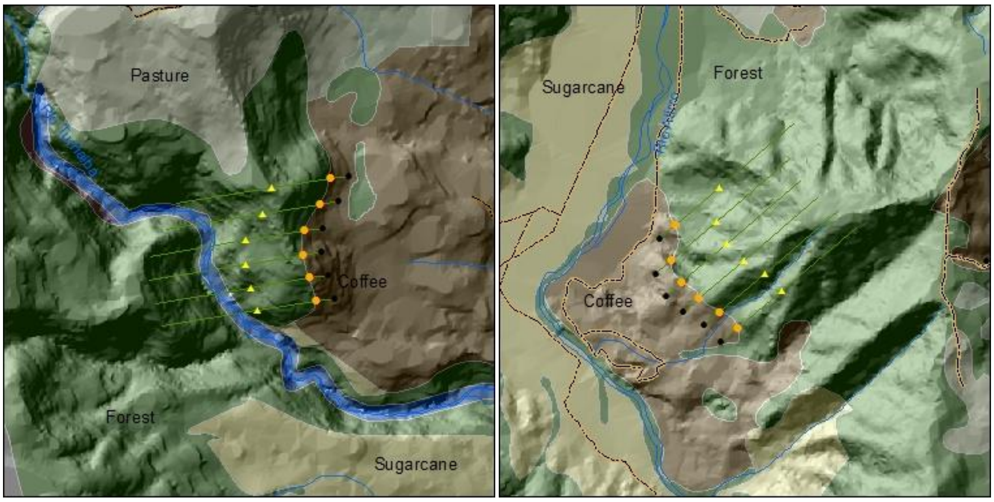


Figura 1.- Ubicación de los transectos para muestreo en Aquiares (izquierda) y en Machina Vieja (derecha)

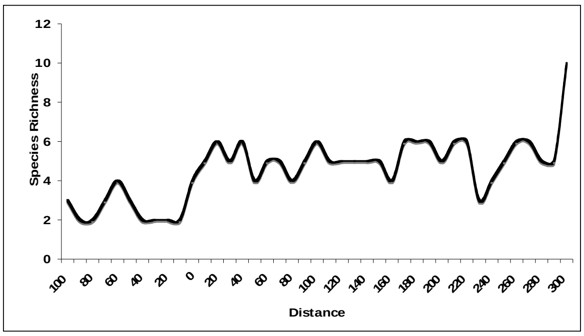
Observamos más de 875 tipos de mamíferos pequeños y medianos pertenecientes a 15 especies en ambas fincas, con un índice promedio de captura de 16 por ciento en ambos sitios. El índice de captura fue el doble de alto en Aquiares y en Machina Vieja. Este es uno de los índices de captura de mamíferos pequeños y medianos más elevados registrados en los trópicos. El índice de captura fue considerablemente mayor en Aquiares, la finca certificada, en comparación con Machina Vieja, que no está certificada. La mayoría de las especies capturadas fueron *Microtus guatemalensis* y *Peromiscus mexicanus* en Aquiares, y *Heteromys oresterus* y *Oryzomys bolivaris* en *Machina Vieja* (Tabla 1). Observamos siete especies adicionales en las trampas cámara colocadas en el bosque adyacente al café.

Tabla 1. Datos de captura por especie de mamíferos capturados en dos fincas cafetaleras en Costa Rica, 2007

Especies	Aquiares			Machina Vieja		
	Captura total	**Recaptura # (%)**	**Índice de captura (%)**	**Captura (#)**	**Recaptura # (%)**	**Índice de captura (%)**
C. capucinus	-	-	-	1	0	0,02%
C. mexicanum	1	0 (0%)	0,02%	-	-	-
C. nigriscens	1	0 (0%)	0,02%	-	-	-
D. marsupialis	4	1 (25%)	0,10%	15	3 (20%)	0,36%
D. virginiana	-	-	-	4	2 (50%)	0,10%
H. oresterus	73	36 (49%)	1,75%	184	110 (60%)	4,41%
M. mexicana	121	74 (61%)	2,90%	-	-	-
M. calinginous	-	-	-	101	53 (52%)	2,42%
M. guatemalensis	308	142 (46%)	7,38%	-	-	-
N. narica	-	-	-	1	0 (0%)	0,02%
N. sumichrasti	-	-	-	2	1 (50%)	0,05%
O. albigularis	68	32 (47%)	1,63%	-	-	-

O. bolivaris	-	-	-	150	79 (53%)	3,59%
P. mexicanus	286	199	6,85%	-	-	-
P. opossum	2	0	0,05%	2	1 (50%)	0,05%
Total	875	487 (56%)	21%	465	252 (54%)	11%

A pesar de los resultados positivos, en realidad se encontraron pocos mamíferos en el café, en donde sobresalieron dos especies (*Peromyscus mexicanus* y *Oryzomys* spp.). Estas dos son especies generalistas que se hallaron tanto en el bosque como en el café. Las 13 especies restantes capturadas sólo se encontraron en la sección boscosa del transecto. Aunque estos resultados se circunscriben a dos fincas, indican que los sistemas agroforestales de café son un hábitat deficiente para mamíferos terrestres, en contraste con la conservación de aves (ver abajo).



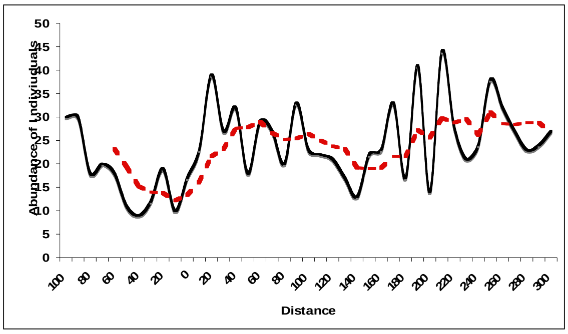


Figura 2. Riqueza de especies (izquierda) y abundancia de datos (derecha) de los mamíferos capturados para el estudio. La parte izquierda del eje "x" (100-0) representa la parte con café del transecto, mientras que la derecha (0-300) simboliza la parte boscosa del transecto.

A pesar de que estas parcelas de café parecen ser fuentes escasas de hábitat para mamíferos, existe una marcada indicación de que el café podría ser un buen amortiguador. Al comparar la abundancia de mamíferos en el límite entre el café y el bosque, no hallamos efectos de límite. Es decir, los mamíferos encontrados a 300 metros del límite del café pudieron haberse hallado también en el límite, sin un incremento observable en la abundancia de las especies con el incremento de la distancia a partir del límite. Esto permite un contraste escueto con un estudio similar realizado en bosques circundantes a pasturas, en donde se encontró un considerable efecto de límite (riqueza y abundancia de especies que aumentaba a mayor distancia del pastura/límite del bosque).

Tales resultados sugieren que, aunque el café podría ser un mal hábitat para la biodiversidad de mamíferos, podría convertirse en un buen amortiguador para mamíferos que dependen del bosque. No obstante, desde la perspectiva de manejo y de certificación del café, también indica que los estándares actuales que procuran el incremento de la cubierta forestal en las plantaciones de café podrían no ser tan eficaces como sería conservar la cubierta forestal alrededor y a lo largo de la plantación de café, en forma de parcelas forestales protegidas o amortiguadores riparios. La ausencia de un efecto de límite también sugiere que los fragmentos forestales muy angostos podrían ser útiles.

Concluimos señalando que el protocolo de muestreo inspiró a Avelino a realizar un estudio similar, pero enfocado en la broca del café en lugar de mamíferos. Los resultados de Avelino, que presentamos en otra sección de este informe, muestran un efecto contrario, es decir, que la broca es común en el café (de manera natural), pero no tanto en los fragmentos boscosos. Estos resultados de CAFNET han fomentado el aporte continuo de fondos por parte de CIRAD y del Servicio de Pesca y Vida Silvestre de los Estados Unidos para el movimiento de la broca y de mamíferos en paisajes donde predomina el café. De nuestros resultados iniciales, concluimos que los elementos del bosque lineal podrían servir de puentes para la biodiversidad de mamíferos y como barrera contra algunas plagas del café.

Figura 3. Dos ocelotes fotografiados en la parte boscosa del área de estudio, uno en Aquiares (izquierda) y el otro en Machina Vieja (derecha).

La conservación de mamíferos en una finca cafetalera con certificación de "Rainforest Alliance"

Participantes en la investigación: Thomas Husband, David Abendon y estudiantes de la Universidad de Rhode Island. Fabrice DeClerck fue el coordinador.

El objetivo principal de nuestra investigación consistió en evaluar el valor de las plantaciones de café como hábitat para las comunidades de mamíferos en Costa Rica. Además, examinamos la comunidad de mamíferos en hábitats boscosos más naturales dentro de entornos donde predomina el café. Hasta ahora, se ha realizado muy poca investigación que examine el uso que hacen los mamíferos de los paisajes donde predomina el café. Se efectuó un inventario de las comunidades de mamíferos en Hacienda La Hilda, una unidad de unas 500 hectáreas de la Compañía Café Tres Generaciones, ubicada cerca de San Pedro de Poás en Costa Rica. La Hacienda La Hilda resultó ideal para nuestro estudio piloto, ya que dentro de sus linderos posee dos de los principales enfoques agrícolas para el cultivo del café (con sol y sombra) y ambos se cultivan con pesticidas y fertilizantes. La ubicación de las oficinas de la Hacienda La Hilda en el área de estudio es N 10°05’35.39” O 84°13’50.76”

Entre el 2005 y el 2007, colocamos trampas en el café (n=4) y en los hábitats boscosos nativos circundantes (n=4). Empleamos trampas cuadriculadas de 6 x 6 que emparejamos con las trampas Sherman en estaciones con 10 metros de separación. En cada grupo de trampas, se colocó una trampa Sherman en el suelo y, cuando fue posible, colgamos la segunda trampa de la vegetación con un alambre a un metro de altura del suelo, aproximadamente. En el segundo punto y en el quinto, en la segunda y quinta línea de cada trampa cuadriculada, colocamos trampas “tomahawk” para capturar mamíferos medianos.

Durante el primer año (2005), capturamos un total de 9.792 Sherman y 544 noche trampas “tomahawk”, entre el 6 y el 22 de junio. En el segundo año (2006), capturamos un total de 7.272 Sherman y 401 noche trampas “tomahawk”, entre el 2 y el 17 de junio. Como nos robaron un tercio de las trampas, la cantidad total de noche trampas disminuyó en el 2006. Por esto, colocamos trampas en las cuadrículas 1, 2 ,7 y 8 durante 17 días y las trampas se movieron de las cuadrículas 5 y 6 a las cuadrículas 3 y 4 el décimo día de captura. Este diseño desbalanceado en el 2006, nos permitió tomar muestras en las cuatro áreas de estudio. En el 2007, capturamos un total de 10.944 Sherman y 532 noches trampa “tomahawk” entre el 1 y el 20 de junio. El esfuerzo total de los tres años fue 30.153 noches trampa.

En el 2004, capturamos 85 mamíferos, 77 en el bosque y 8 en los cafetales (Tabla 1). En total, capturamos 4 especies en el cafetal y 10 en las cuadrículas de bosque circundante. Los mamíferos observados de modo oportunista en el 2005 fueron coyotes (*Canis latrans) y* perezosos de tres dedos (*Bradypus variegates).* En el 2006, capturamos 133 mamíferos, de los cuales 114 se capturaron en el bosque y 18 en los cafetales (Tabla 1). Observamos *Choloepus hoffmanii* en un árbol cerca de las cuadrículas 6-7, que es un área de café de sombra. Para una mejor comparación de los resultados entre años y cuadrículas con noches trampa desiguales, modificamos los datos de captura para que reflejaran las cifras capturadas por 1.000 noches trampa (Tabla 1). Un prueba t pareada de la totalidad de los datos (2005-2007) mostró que había más mamíferos en las cuadrículas de bosque (P=0,0003, n=24) que en las cuadrículas de café circundantes.

Los resultados de nuestro estudio son intrigantes (Figuras 4 y 5) porque demuestran que en los cafetales habitan mucho menos mamíferos que en el bosque circundante. De hecho, la cantidad de individuos mamíferos terrestres que encontramos en las cuadrículas del bosque era 9,7 veces mayor que los encontrados en el café de sol y 4,6 veces mayor que aquellos que hallamos en el café de sombra. Es probable que este sea el hallazgo más importante del estudio.

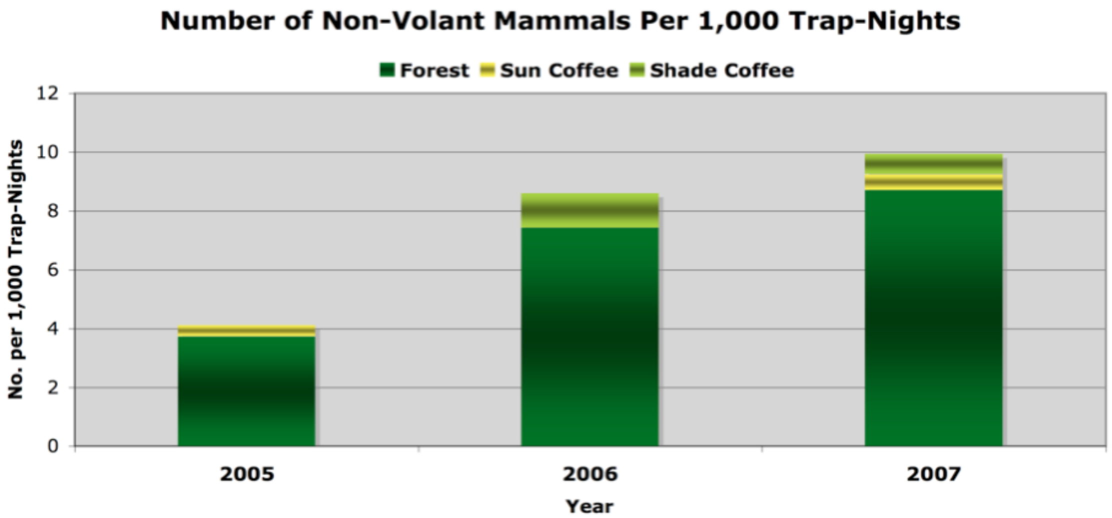


Figura 4: La cantidad de individuos capturados por 1.000 noches trampa por año en Hacienda La Hilda en parcelas, café de sol o café de sombra. Observe que, en el 2005, sólo se tomaron muestran en el café de sol y en el 2006, sólo en el café de sombra. Se tomaron muestras de ambas en el 2007.

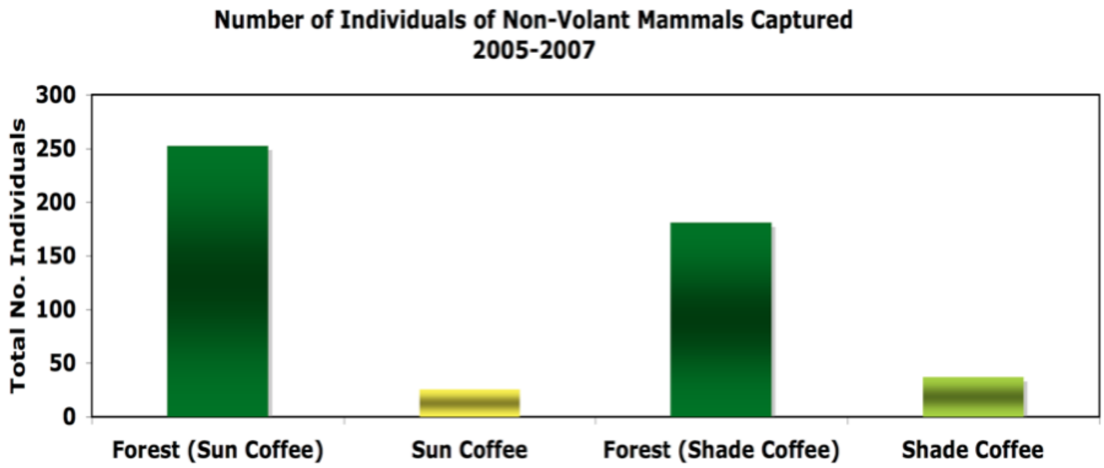


Figura 5: La cifra total de mamíferos capturados en Hacienda La Hilda. Bosque (café de sol) se refiere a las parcelas de bosque circundantes al café de sol; en contraposición, Bosque (café de sombra) se refiere a las parcelas de bosque circundantes al café de sombra.

Aunque relativamente pequeñas y aisladas, las parcelas de bosque en un paisaje donde predomina el café, albergaban, con frecuencia, una gran diversidad de mamíferos pequeños y medianos (7 de 12 cuadrículas en pares) y siempre mantuvieron una mayor abundancia de mamíferos en comparación con el café circundante. De hecho, en esas 5 cuadrículas pareadas, donde la diversidad era más alta en el café, la cantidad de mamíferos capturados en el bosque circundante fue 9,7 veces mayor.

Nuestros datos muestran que las etapas tempranas consecutivas del bosque mantienen niveles más altos de diversidad de mamíferos pequeños que las etapas posteriores. Detectamos grandes cantidades de mamíferos, pero sólo de unas pocas especies, en las cuadrículas del bosque que estaban en etapas posteriores de la serie consecutiva.

El trabajo cooperativo sobre mamíferos entre la Universidad de Rhode Island y el CATIE continuará incluso cuando CAFNET finalice. Dicha labor da impulso a los resultados obtenidos por los investigadores de CAFNET. En particular, las cuadrículas de investigación usadas por DeClerck y Avelino las utiliza Mandi Caudill, estudiante de posgrado en la Universidad de Rhode Island, para el muestreo de mamíferos con el fin de probar si es posible distribuir árboles que actúen como barrera contra escarabajos y como puente para los mamíferos, en los paisajes donde predomina el café. Las referencias del trabajo de la Universidad de Rhode Island se financiaron con las matrículas de los estudiantes y un subsidio del Ministerio de Agricultura de los EE.UU. (USDA) que complementó el financiamiento de CAFNET. El financiamiento de USDA también cubrió el viaje de DeClerck a Rhode Island para compartir las lecciones aprendidas sobre las certificaciones del café en los neotrópicos.

Valor de conservación de los sistemas agroforestales de café para la biodiversidad de aves

Participantes en la investigación: Fabrice DeClerck y Alejandra Martínez-Salinas y una asombrosa cantidad de voluntarios.

El fundamento del movimiento de conservación del café en Centroamérica se ha centrado en las aves y, en particular, en las aves migratorias neotropicales, según lo demuestran las normativas de certificación del

Smithsonian Bird Friendly. Entre los estándares existentes, el smithsoniano es el más estricto y exige una certificación orgánica, además de una cubierta de copas de mayor tamaño formada por varias especies. Muchas de las normativas de certificación adoptadas por *Rainforest Alliance, Starbucks* y Nestlé se desprenden del estudio original conducido por los científicos smithsonianos.
Sin embargo, a pesar de este gran esfuerzo, la mayoría aun no incluye mucha información sobre el valor de conservación de los sistemas agroforestales de café y, en particular, sobre la manera en que los esfuerzos de manejo afectan la conservación de aves. Para contribuir al cierre de esta brecha, establecimos una iniciativa de monitoreo de aves a largo plazo en el CATIE en enero de 2008. Esta iniciativa de monitoreo incluye el redes de niebla tres veces por semana (entre 5-9 a.m.) en seis de los usos de suelos: (1) bosque, (2) cañaverales, (3) cercas vivas en pasturas, (4) sistemas agroforestales de cacao (5) *Smithsonian Bird Friendly* como el café, y (6) café con poró (*Erythrinia poeppigiana*). Los dos usos del suelo del café representan los extremos de manejo en Costa Rica. El café con poró es el estándar, con árboles muy podados espaciados cada 10 m aproximadamente. Por otro lado, el café smithsoniano es de sombra profunda y baja productividad. Los otros cuatro usos del suelo se utilizan como unidades de comparación.

Desde el inicio del proyecto, hemos capturado, identificado, medido y anillado más de 5.000 aves pertenecientes a más de 178 especies. Encontramos una gran mayoría de estas en dos de los suelos para café, y ambos han generado la mayor abundancia de aves en comparación con los otros dos lugares. Como es de esperar, la parte del café smithsoniano produjo la mayor riqueza de especies, con más de 80 especies capturadas. Entre ellas, hallamos especies que dependen del bosque que no encontramos en otros usos del suelo. El sitio con café con poró también mostró una sorprendente cantidad de especies (65); sin embargo, este valor resultó semejante al sitio de cercas vivas en pasturas y menor en el sitio del sistema agroforestal de cacao. El sitio boscoso mostró la menor riqueza y abundancia de especies, seguido por el cañaveral. La creciente diversidad forestal en los sistemas agroforestales de café aumenta significativamente su valor de conservación y, a diferencia de los resultados de los mamíferos anteriormente descritos, la biodiversidad de aves se encuentra comúnmente en los sistemas agroforestales de café.

No obstante, es posible que un análisis de la composición de las especies resulte más convincente que un análisis de abundancia y riqueza. Realizamos un escalamiento métrico multidimensional de las especies encontradas en los seis sitios de estudio (Figura 4) y hallamos que la composición de las especies podía clasificarse en cuatro amplios grupos. Los primeros son las pasturas (ESCV) y los cañaverales (CAAZ) que comparten muchas especies, especialmente granívoras. En la mitad del diagrama se ubican los sistemas agroforestales de café (CAPO y CAAB) dominados por migrantes neotrópicos, particularmente currucas (Figura 5), que no son tan comunes en otros sitios. Este resultado respalda el marcado interés de los grupos conservacionistas de los Estados Unidos en el valor de conservación de los sistemas agroforestales de café. El sistema agroforestal de cacao (CAOR) se encuentra a la izquierda de los cafetales; indicando que comparten muchas especies, pero comparte una composición mayor con el bosque que con los cafetales. Por último, el bosque (BOSQ) se encuentra relativamente aislado en la parte izquierda superior del diagrama. Esto indica que comparte muy pocas especies con otros usos del suelo. La importancia de estos resultados es que, conforme se incorporan árboles en los sistemas agroforestales de café y cacao, éstos tienden a compartir más especies con los sistemas de pastos (pasturas y cañaverales); sin embargo, a pesar del valor añadido de estos árboles, los sistemas agroforestales todavía se quedan cortos en la duplicación de la composición de especies de los sistemas forestales. Interpretamos esta conclusión dando a entender que, en efecto, los sistemas agroforestales de café sustentan la conservación de la biodiversidad de aves, pero no son capaces de ofrecer un hábitat con especies que dependan del bosque que son del mayor interés de la conservación.

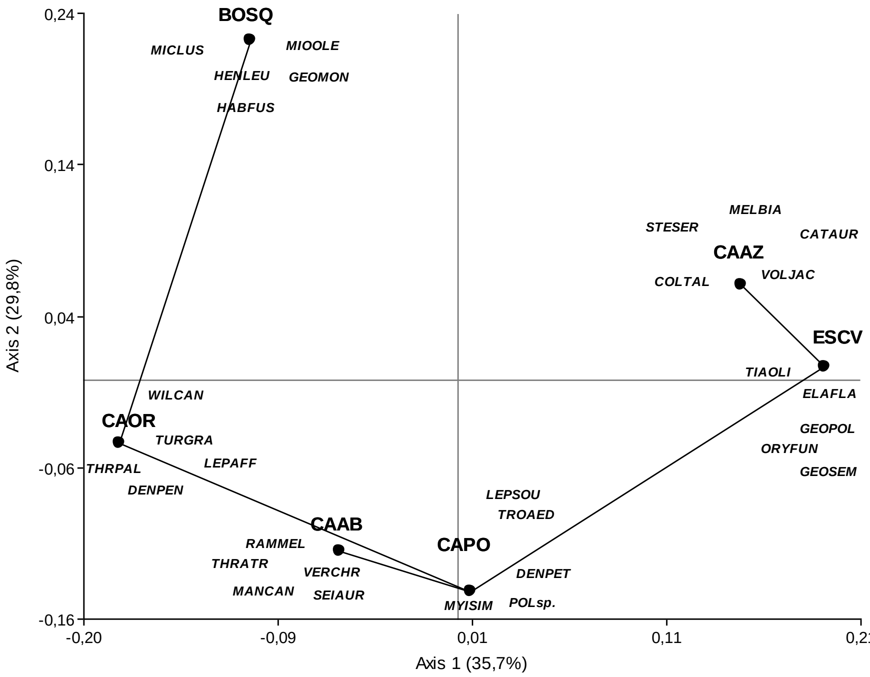


Figura 4: Ordenamiento de las especies encontradas en los seis usos del suelo incluidos en el estudio. Observe que el café con poró (CAPO) y el café smithsoniano (CAAB) se ubican en la mitad del diagrama. A pesar de que estos sitios contaban con una gran riqueza y abundancia de especies, fueron incapaces de reproducir la composición de especies hallada en el bosque (BOSQ).

La ventaja de usar técnicas de redes de niebla en los estudios de aves es que permite observar la salud de las aves y su estado reproductivo. A la vez, esta información puede utilizarse como ayuda en la toma de decisiones de manejo. Por ejemplo, el café con poró se poda, por lo general, dos veces al año para el manejo de la sombra. En un solo año, el cierre de la cobertura en dicha plantación puede variar de 0% después de la poda a >80% seis meses después y regresar a 0% después de la segunda poda. El objetivo principal de esta poda es controlar la sombra del café; sin embargo, observamos dos posibles consecuencias para la conservación de aves. Primero, la poda suele coincidir con la época de anidamiento de las especies neotropicales residentes, que es cada año entre abril y julio. Además, es en esta época cuando las aves migratorias neotropicales regresan a los Estados Unidos y Canadá, y cuando podrían ser más vulnerables a los cambios en los recursos disponibles en el café. Desde una perspectiva conservacionista, todo manejo intenso como la poda del café o de los árboles de sombra, o las aplicaciones directas de agroquímicos debería evitarse en esta época, en la medida de lo posible.

Por último, deseamos señalar la contribución de los sistemas agroforestales de café en la conservación de las aves migratorias neotropicales. Estas especies, compuestas principalmente por currucas, tangaras y tordos, invernan en los neotrópicos y se reproducen en latitudes templadas. Son muy vulnerables a los cambios en el uso del suelo debido a las grandes distancias que deben volar. El hábitat para invernar en los trópicos es de especial importancia, ya que permite a estas especies acumular reservas de grasa y energía para regresar a las regiones templadas. Una gran mayoría de las especies migratorias prefiere los sistemas agroforestales de café, en donde hallamos más del doble de individuos en cafetales en comparación con los demás sitios.

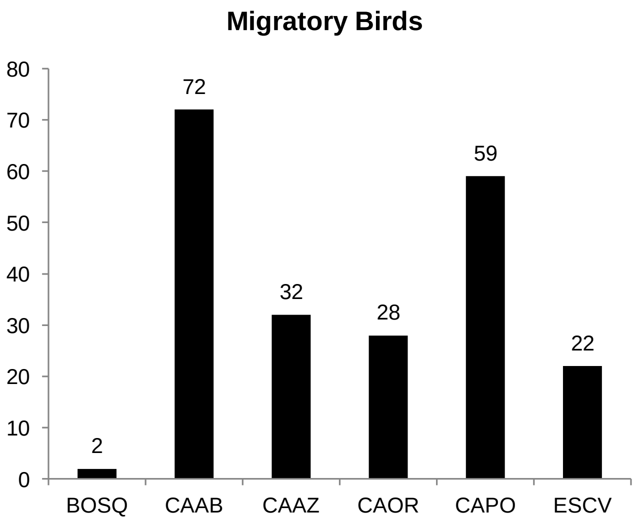


Figura 5: Afluencia de especies de migratorias según el uso del suelo: Bosque (BOSQ), café smithsoniano (CAAB), caña (CAAZ), cacao (CAOR), café con poró (CAPO) y cercas vivas en pasturas**.**

Conclusión

Los sistemas agroforestales han sido favorecidos por mucho tiempo por su función potencial en la conservación de la biodiversidad. Nuestro análisis sugiere que esta función parece evidente para la biodiversidad de aves, pero no lo es tanto para las especies mamíferas. Sin embargo, aunque muchas especies de aves encuentran su hábitat en los sistemas agroforestales de café, no observamos aquellas especies con el mayor interés de conservación, excepto por las aves migratorias neotropicales, que utilizan los sistemas agroforestales de café como hábitat estable. El incremento de la presencia de especies que dependen del bosque sólo es posible en la medida en que los sistemas agroforestales se manejen para asemejarlos mucho más en estructura y en composición a los bosques nativos. Esto parece poco probable si consideramos la gran oposición de los agricultores de crear sombras más profundas, como lo proponen los investigadores smithsonianos. Una estrategia alterna de manejo sería reducir la sombra en los cafetales, pero mantener los fragmentos boscosos o los elementos del bosque lineal en la periferia de los cafetales. Tal organización especial aumentaría la presencia de especies que dependen del bosque en las fincas cafetaleras y, además, contribuiría con los servicios de control de plagas (ver el informe de Avelino incluido aquí), incrementaría la conectividad de la biodiversidad silvestre y ofrecería servicios ecosistémicos.

Los resultados de CAFNET del Proyecto de Monitoreo de Aves y Mamíferos han sido de gran valor, y los seguimos utilizando para ampliar nuestra comprensión de la contribución de la conservación de la biodiversidad en el manejo y producción del café. Por ejemplo, los nuevos estudios que se desprenden del estudio original de CAFNET se centrarán en la función de los elementos de árboles lineales para limitar la propagación de la broca y aumentar la presencia de predadores de la broca, como las currucas. Los resultados del componente de biodiversidad de CAFNET fueron fundamentales para el capítulo del libro escrito por DeClerck y Martínez-Salinas (2011) sobre la medición de la biodiversidad. El capítulo analiza las formas para evaluar la biodiversidad en los sistemas agroforestales, concentrándose en los esquemas de certificación. Varios ensayos de evaluación por parte de expertos internacionales están en proceso de publicación, pero aún no han sido aceptados ni presentados.

Personal	**Biodiversidad de mamíferos y aves en los paisajes agrícolas**
Investigadores Fabrice DeClerck Alejandra Martínez Thomas Husband David Abedon	 11 meses-hombre 11 meses-hombre 4 meses-hombre 4 meses-hombre
Personal técnico Natalia Estrada Carmona	 1 meses-hombre
Voluntarios (Proyecto de Aves del CATIE) Estudiantes (Proyecto de mamíferos del URI)	33 meses-hombre 15 meses-hombre

Publicaciones por presentar

DeClerck, F.A.J. M.J. Gomez, N. Estrada Carmona, V. Loaiza, S. Olsen, C. Yzoard, D. Abedon and T. Husband. (in Prep). Living on the edge: coffee agroforests serve as buffers for small and medium mammals. Biological Conservation.

Martinez-Salinas, A., and F.A.J. DeClerck. (in Press) The role of agroecosystems in the conservation of birds within biological corridors. Revista de recursos naturales. Turrialba, Costa Rica.

Capítulos de libros

Avelino J., ten Hoopen M., DeClerck F. 2011. Ecological Mechanisms for Pest and Disease Control in Coffee and Cacao Agroecosystems of the Neotropics En: Ecosystem Services from Agriculture and Agroforestry. Measurement and Payment. Editado por Bruno Rapidel, Fabrice DeClerck, Jean-Francois Le Coq y John Beer. Earthscan. p. 91-118.

DeClerck, F.A.J., Martinez-Salinas, A., 2011. Measuring Biodiversity, In Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. eds B. Rapidel, F.A.J. DeClerck, J. Le Coq, J. Beer, pp. 65-90. Earthscan, Londres.

DeClerck, F.A.J., Le Coq, J., 2011. The Value of Biodiversity in Agricultural Landscapes, In Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. eds B. Rapidel, F.A.J. DeClerck, J. Le Coq, J. Beer, pp. 215-236. Earthscan, Londres.

Presentaciones

DeClerck, F.A.J. 2010. The Contribution of Agricultural Landscapes to Connectivity in Biological Corridors. (Keynote). Mesoamerican Congress on Biological Conservation, San José, Costa Rica.

DeClerck, F.A.J., M. Gomez, D. Abedon and T. Husband. 2009. Living on the Edge: Tree arrangement, forest edges, and mammal conservation in coffee agroforests of Costa Rica. II Congreso Mundial de Sistemas Agroforestales. Nairobi, Kenia.

DeClerck, F.A.J. 2011. The Value of Biodiversity. EfD Seminar. CATIE, Turrialba, Costa Rica. Martínez Salinas, A. y F.A.J. DeClerck. 2010. Contribución de sistemas agroforestales a la conservación de la avifauna en el Corredor Biológico Volcánica Central Talamanca, Costa Rica. Asociación de Ornitólogos de Costa Rica. San José, Costa Rica.

DeClerck, F.A.J. 2009. La conservación de biodiversidad en sistemas agrícolas del Corredor Biológico Volcánica Central Talamanca. Feria de devolución de información a productores cafetaleros. Turrialba, Costa Rica.

DeClerck, F.A.J. 2010. Contribucion des Systemes Agro-Forestiers a la Conservacion de la biodiversite dans le corridor mesoamericain. Meeting of the ATP Omega 3. Montpellier, Francia.

DeClerck, F.A.J. and A. Martinez-Salinas. 2010. Mixing the Matrix: Participatory Avian Biodiversity monitoring within the VCTBC, parks, pastures and coffee. Presentado a Asistentes del Congreso de EE.UU, Turrialba, Costa Rica

DeClerck, F.A.J. 2010. Conservación en la matriz agrícola del corredor biológico Volcánica Central Talamanca; Conectividad y ritmos anuales. Asociación de Ornitólogos de Costa Rica. San José Costa Rica.

DeClerck, F.A.J. 2010. Certification for Biodiversity. Presentado al Ministerio de Agricultura de Rhode Island. Providence, Rhode Island.

DeClerck, F.A.J. 2010. Biodiversity Conservation and Ecosystem Function in Agricultural Landscapes. Rhode Island University.

Martinez-Salinas, A.M., and F.A.J. DeClerck. 2009. Annual bird dynamics and use of coffee, and cacao agroforest, silvopastoral systems, sugar cane and forest land uses in Turrialba Costa Rica. II Congreso Mundial de Sistemas Agroforestales. Nairobi, Kenia. *Receptora del Premio Poster a la "Mayor innovación en sistemas agroforestales"*

Martinez-Salinas, A. and Fabrice DeClerck. Coffee Biodiversity in Costa Rica. Rainforest Alliance Workshop of Reviewing Certification Standards. San José, Costa Rica. 2009.

Martinez-Salinas, A., Declerck, CF. Bird dynamics and use of coffee and cacao agroforests, silvopastoral systems, sugar cane and forest land uses in the Central Volcanic Talamanca Biological Corridor, Costa Rica

5.Evaluación de impactos ambientales de los sistemas agroforestales con café

5.1.Estudio huella de carbón

Jeremy Haggar
Gabriela Soto
Martin Noponen
Cliserio González
Nicola Attarzadeh

Se desarrollaron metodologías para la medición de la huella de carbono en café, el secuestro de carbono y el balance final. Utilizando las metodologías de PA2050 se compararon las huellas de carbono en fincas certificadas Rainforest Alliance y orgánicas, con fincas convencionales en Nicaragua y en Costa Rica, encontrándose que las fincas orgánicas tienen la menor huella de emisiones de gases efecto invernadero en los dos países, siendo menor la huella en las fincas orgánicas de Nicaragua comparadas con las de Costa Rica. No se observaron diferencias entre las fincas certificadas Rainforest Alliance y las fincas convencionales en ninguno de los dos países. El factor que mayor impacta la huella de carbono es la aplicación de fertilizantes nitrogenados tanto de origen natural como sintéticos. Se analizan y discuten cuestionamientos sobre la emisión de oxido nitroso de los residuos de las podas de los árboles de sombra leguminosos como la Erythrina sp., cuyo aporte de biomasa hace un significativo aporte de nitrógeno al sistemas.

Se cuantificó a nivel de ensayo de sistemas del CATIE y a nivel de fincas de productores en Nicaragua y Costa Rica el balance de carbono. En los Ensayos comparativos de sistemas orgánicos y convencionales establecidos por el CATIE desde el 2001 en Costa Rica y Nicaragua se encontró que la huella de carbono (HC) de producción de 1 kg de café cereza varió de 0.12 – 0.52 kgCO_2e para los sistemas orgánico, y de 0.26 a 0.67 kgCO_2e / 1 kg de café cereza para los sistemas convencionales. Las prácticas de manejo que tuvieron un mayor impacto en la huella de carbono fueron los fertilizantes nitrogenados (sintéticos y naturales), ocasionando un 46% de la huella de carbono en sistemas convencionales y un 87% en los sistemas orgánicos. Las emisiones de oxido nitroso por aportes de las podas contribuyeron un 7% (Alto convencional) y un 42% (Orgánico Bajo). Estos estimados están afectados por la selección del factor de emisión que se utilicen en los cálculos. Diferencias en los factores de emisión generan una variación de un 14 a un 40% en los sistemas convencional y de un 24 a un 244% en los sistemas orgánicos. El poco impacto que tuvo el tipo de sombra permite sugerir que se puede predecir la huella de carbono de un sistema basándose sobre todo en los insumos utilizados. Sin embargo se recomiendan más estudios en sitios específicos, a la par de metodologías más precisas con factores de emisiones regionales.

En los estudios realizados en finca en Costa Rica (Orosi y Turrialba) y Nicaragua (Masatepe) se encontraron resultados similares. La HC de 1 kg de café cereza en Costa Rica varió de 0.06 a 0.55 (promedio 0.39) kgCO_2e en fincas convencionales y de 0.19 – 0.54 (promedio 0.38) kgCO_2e en fincas orgánicas. En Nicaragua la HC varió de 0.12 a 1.10 (promedio 0.40) kgCO_2e en fincas convencionales y 0.01 – 0.10 (promedio 0.06) kgCO_2e en fincas orgánicas. De nuevo el factor que mayor explica la HC son los aportes de fertilizantes nitrogenados sintéticos y naturales, explicando hasta el 91% de la HC en los diferentes sistemas.

5.2.Almacenamiento de carbono en fincas certificadas

Jeremy Haggar
Gabriela Soto
José Pico
Elias de Melo Virginio Filho

Se utilizó la metodología conocida como Land Use, Land use Change and Forestry (LULUC) del Intergovernmental panel on climate change (IPCC, 2003), la cual permitió estimar el carbono almacenado en biomasa con base en la medición de la altura total y diámetro a la altura del pecho (dap) de árboles y arbustos mediante el uso de modelos alométricos específicos de las especies. Adicionalmente se estimó el carbono en los suelos, necromasa (hojarasca, madera muerta) y hierba. Como resultados en biomasa se encontró 27.93, 26.94, 18.20 y 13.21 tC ha-1 en cafetales certificados como orgánicos, Fair Trade, Rain Forest y convencionales respectivamente. Los volúmenes de carbono orgánico del suelo fueron de 120.2, 111.56, 104.65 y 80.78 en orgánicos, Rain Forest, Fair trade y convencionles respectivamente. El almacenamiento total fue de 142.66 para orgánico, 128.54 Rain Forest, 123.94 Fair trade y 93.50 en convencionales. Para las emisiones se consideró los volúmenes de fertilizantes, enmiendas cálcicas y combustibles fósiles, encontrando emisiones de 0.19, 0.46, 0.41 y 0.33 tC ha-1 en orgánico, Rain Forest, Fair Trade y convencional respectivamente, sin encontrar diferencias significativas. La certificación orgánica tiene los mayores volúmenes de almacenamiento y menores de emisiones considerando todos los reservorios y fuentes de emisión. El valor más alto de emisión lo presentó Rain Forest.

6.Validación participativa de prácticas agroforestales sostenibles.

Elias de Melo Virginio-CATIE
eliasdem@catie.ac.cr
Beatriz Elizondo-CATIE
Roberto Jerez-CATIE
Alma Quilo-ANACAFE
Rudy Del Cid-DEFENSORES
Wilber Montenegro
Eduardo Neves-USP
Sonia Banessa-UNA
Carlos Zapata-UNA

El componente del proyecto CAFNET de validación de prácticas agroforestales bajo diferentes enfoques de manejo fue desarrollado de manera colaborativa con diferentes socios en Costa Rica, Nicaragua y

Guatemala. El objetivo propuesto al inicio del proyecto fue el de que *" a partir de la síntesis de conocimientos entre científicos, técnicos locales y productores desarrollar una red de parcelas de aprendizaje que permita validar y promover opciones de manejo agroforestal sostenible en cafetales de las diferentes zonas de producción."* El cuadro 1 presenta información resumida sobre número de fincas involucradas directamente, manejos y certificaciones involucradas y las instituciones y organizaciones que participaron en los diferentes países.

Cuadro 1. Número de fincas, comunidades, manejos y certificaciones y instituciones involucradas

Países	Nº Fincas	N° Comunidades	MANEJOS Y CERTIFICACIONES DE LAS FINCAS INVOLUCRADAS	INSTITUCIONES Y ORGANIZACIONES PARTICIPANTES
COSTA RICA	20	19	-ORGÁNICAS -RAINFOREST-CONVENCIONALES -UTS CERTIFIED-CONVENCIONALES -AAA-NESPRESSO-CONVENCIONALES	-APOT -FJ ORLICH-ECOM -ICAFE -EMPRESA JORGE CUTIÉ -CAFETALERA AQUIARES -UCR
NICARAGUA	27	18	-ORGÁNICAS -UTS CERTIFIED-CONVENCIONALES -CONVENCIONALES SIN SELLOS	-COMPROCON (4 fincas c CAFNET + 16 incorporadas por la organización) -GUARDIANES DEL BOSQUE -CECOCAFEN/COMANUR
GUATEMALA	27	16	-ORGÁNICAS -CONVENCIONALES SIN SELLOS	-ANACAFE -DEFENSORES DE LA NATURALEZA -ADIPSA -ASOCIACION ALBOREZ -EMPRESA JESUS RAMIREZ
TOTAL	**74**	**53**		

Entre los principales temas de las experiencias participativas de validación en fincas de aprendizaje están:

- 1. Diseño, rediseño y manejo sombra diversificada (café, ambiente, economía, finca);
- 2. Combinaciones integradas de Manejo de tejido, manejo selectivo de hierbas, enmiendas orgánicas/biomasa en cafetales con sombra;
- 3. Reducción de herbicidas en manejo selectivo de hierbas y formulas nitrogenadas;
- 4. Tipos manejo de sombra;
- 5. Manejo integrado de plagas en cafetales con sombra;

A finales del 2010 se realiza una serie de evaluaciones de campo y sondeos con productores(as) experimentadores (as) que participaron de las actividades. Los principales resultados identificados para los tres países están resumidos a continuación. Un 90,33% de los experimentadores(as) en los tres países afirmaron que el proceso de validación participativa de prácticas agroforestales sostenibles los motivó a repensar ajustes necesarios en el manejo de sus sistemas productivos con café y el 95,33% de ellos(as) coinciden que la metodología utilizada fue muy importante para garantizar los aprendizajes logrados, (Cuadro 2).

Cuadro 2. Valoración de la metodología de validación por los(as) productores(as) experimentadores(as) y motivación a cambios en los cafetales en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación
Costa Rica	100%	**90,33%**	Indicaron que **el proyecto los motivó** a pensar en cambios necesarios en el cafetal.
Nicaragua	100%		
Guatemala	71%		
Costa Rica	100%	**95,33%**	Indicaron que la metodología de parcelas de prueba fue **muy importante** para los aprendizajes.
Nicaragua	100%		
Guatemala	86%		

Fuente: sondeo con los productores(as) experimentadores(as) participantes del proyecto 2010.

Con relación a los diseños y manejo de sombra probados (Cuadro 3) un 75,78% de los participantes afirmaron que haber identificados cambios positivos cuanto a la regulación de la sombra en sus cafetales.

Cuadro 3. Consideración sobre los diseños y manejo de sombras probados en parcelas de validación en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación (Diseño y manejo de sombra)
Costa Rica	83,33%	**75,78%**	Indicaron que **hubo cambios positivos** (regulación adecuada de luz con niveles intermedios) en la sombra de las parcelas de prueba.
Nicaragua	73,00%		
Guatemala	71,00%		

Fuente: sondeo con los productores(as) experimentadores(as) participantes del proyecto 2010.

Para un 84% promedio de los(as) experimentadores(as) hubieron resultados positivos cuanto al manejo de tejido practicado en las parcelas de validación lográndose un mayor vigor y desarrollo de cafetos, (Cuadro

4). Además de la percepción de productores (as) basadas en las observaciones entre parcelas de prueba y parcelas testigo (sin tratamiento o con tratamiento tradicional), se realizaron toma de datos y estas confirman el criterio de análisis de los(as) productores(as).

Cuadro 4. Consideración sobre las prácticas de podas y deshijas probadas en parcelas de validación en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación (Manejo de tejido: podas, deshijas)
Costa Rica	100%	**84%**	Los productores indican que hubo resultados positivos (**mayor vigor y desarrollo**) en las parcelas de prueba en contraste con las parcelas testigo. Nota: toma de datos en las parcelas confirman que la percepción de los productores es correcta.
Nicaragua	73%		
Guatemala	79%		

Fuente: sondeo y toma de datos en parcelas con los productores(as) experimentadores(as) participantes del proyecto 2010.

Uno de los temas importantes en la investigación participativa fue la incorporación de abonos orgánicos y reducción de dosis de fertilizantes sintéticos. En promedio para los tres países el 75% de los(as) experimentadores(as) observaron resultados positivos en las parcelas de tratamiento en comparación con parcelas testigo (manejo tradicional), (Cuadro 5).

Cuadro 5. Consideración sobre los ajustes en la fertilización de cafetales en las parcelas de validación en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación (Fertilización de cafetales: incorporación de abonos orgánicos y reducción de fertilizantes convencionales)
Costa Rica	70%	**75%**	Los productores indican **resultados preliminares positivos** en las parcelas de
Nicaragua	91%		

Guatemala	64%		prueba en contraste con las parcelas testigo;

Fuente: sondeo con los productores(as) experimentadores(as) participantes del proyecto 2010.

Otro aspecto considerado en la validación de prácticas fueron alternativas de manejo de la cobertura del suelo, en particular el manejo selectivo de buenas coberturas y mantenimiento de hojarasca originada de los árboles de sombra. Para un 64,5 % promedio de las fincas que probaron estas prácticas los(as) experimentadores(as) locales expresaron haber logrado resultados positivos en control de malas hierbas y en protección del suelo, (Cuadro 6).

Cuadro 6 Consideración sobre los resultados de la validación de manejo de la cobertura de los suelos en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación (Manejo de cobertura del suelo: hojarasca y manejo selectivo de buenas hierbas)
Costa Rica	62,5%	**64,5%**	Los productores indican que hubo resultados positivos **(control malas hierbas, protección suelo)** en las parcelas de prueba en contraste con las parcelas testigo.
Nicaragua	64,0%		
Guatemala	67,0%		

Fuente: sondeo con los productores(as) experimentadores(as) participantes del proyecto 2010.

Cuanto a las prácticas de control de plagas y enfermedades probadas un 50,67% promedio de los productores(as) indicaron haber conseguido resultados positivos. Para Guatemala solo un 20% de los(as) experimentadoras lograron resultados positivos en las parcelas de validación, (Cuadro 7).

Cuadro 7. Consideraciones sobre las prácticas de control de plagas y enfermedades en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación (Control de plagas y enfermedades)
Costa Rica	50%	**50,67%**	Los productores indican que hubo control en las parcelas de prueba en contraste con las parcelas testigo. Nota: *En Guatemala la toma de datos en parcelas confirma la percepción de productores para control de ojo de gallo y mancha de hierro, pero roya y antracnosis no hubo cambios.
Nicaragua	73%		
Guatemala	29%*		

Fuente: sondeo y toma de datos en parcelas con los productores(as) experimentadores(as) participantes del proyecto 2010.

Para el parámetro vigor de cafetos un 77,5% promedio de los (as) experimentadores(as) expresaron que las parcelas con tratamientos presentaban mejor vigor que las parcelas testigo (manejo tradicional). Por otro lado, como promedio de los tres países un 53,3% de los productores(as) afirmaron haber logrado aumento de producción de café en las parcelas con tratamiento en comparación con las parcelas testigo con manejo tradicional. Para Nicaragua un 64% de las fincas reportaron aumento de producción, Costa Rica un 53% y Guatemala un 43%, (Cuadro 8). Considerando que en general para ver impactos en la producción de café se requiere un seguimiento de mediano a largo plazo estos resultados son satisfactorios y prometedores.

Cuadro 8. Consideraciones sobre evaluación de vigor y producción de café en parcelas de validación en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación (Cambios en vigor y producción de los cafetos)
Costa Rica	62,5%	**77,5 %**	Los productores indican que hubo cambios positivos en **vigor** en las parcelas de prueba en contraste con las parcelas testigo.
Nicaragua	91,0%		
Guatemala	79,0%		
Costa Rica	53%	**53,3%**	Indicaron que haber **aumentado la producción** de café en las parcelas de prueba en comparación con parcelas testigo. ***Nota= confirmado por toma de datos en parcelas.**
Nicaragua	64%*		
Guatemala	43%*		

Fuente: sondeo y toma de datos en parcelas con los productores(as) experimentadores(as) participantes del proyecto 2010.

Para un 41, 33% promedio de los tres países los experimentadores(as) indican que las prácticas validadas representaron un aumento de labores, para un 30,33% la cantidad fue igual que el manejo tradicional y un 28,33% que la cantidad de labores fue menor, (Cuadro 9). Considerando la amplitud de resultados positivos logrados con las prácticas agroforestales validadas es importante el hecho de que en promedio un 58,66% de los(as) experimentadores (as) tuvieran igual o menor cantidad de labores con las opciones probadas. Para Guatemala se presentó un 71% de fincas reportando aumento de labores en relación a las prácticas tradicionales, mientras que para Nicaragua un 73% de las fincas indican que las prácticas validadas representaron una menor cantidad de labores en relación al manejo tradicional, mientras para Costa Rica un 53% reportaron un aumento de labores y un 47% igual o menor cantidad de labores con las nuevas prácticas.

Cuadro 9. Consideraciones de los productores(as) sobre la demanda de tiempo generada por las prácticas agroforestales validadas en comparación con los manejos tradicionales en los tres países. CATIE-CAFNET-CIRAD.

País	Aumentó labores		Igual cantidad de labores		Menor cantidad de labores	
	% Finqueros	% Promedio	% Finqueros	% Promedio	% Finqueros	% Promedio
Costa Rica	53%		35%		12%	

Nicaragua	0%	**41,33**	27%	**30,33**	73%	**28,33**
Guatemala	71%		29%		0%	

Fuente: sondeo con los productores(as) experimentadores(as) participantes del proyecto 2010.

Un parámetro muy importante sobre el impacto del componente de validación participativa de prácticas agroforestales sostenibles era la adopción de las mismas en las fincas cafetaleras a partir de aprendizaje en parcelas de prueba. En este sentido un 80% promedio de los(as) experimentadores(as) locales comentaron haber hecho cambios en sus cafetales a partir de lo aprendido en la investigación participativa. Para el caso de Guatemala un 93% de los(as) productores(as) indicaron haber hecho cambios, seguidos por un 82% de los(as) experimentadores(as) de Nicaragua y un 65% de Costa Rica, (Cuadro 10), pasando este resultado ser uno de los referentes más importantes del impacto logrado por el componente del proyecto.

Cuadro 10 Consideración sobre cambios realizados en todo el cafetal a partir del aprendizaje en parcelas de validación en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación (Proceso motivando cambios en todo el cafetal)
Costa Rica	65%	**80%**	Indicaron haber hecho cambios al cafetal a partir de lo aprendido en las parcelas de prueba
Nicaragua	82%		
Guatemala	93%		

Fuente: sondeo con los productores(as) experimentadores(as) participantes del proyecto 2010.

Otro aspecto importante considerado en el sondeo realizado fue identificar cuantos experimentadores(as) habían comunicado a sus vecinos los aprendizajes logrados en parcelas de validación y en sus fincas. En promedio para los tres países 67,3% de los experimentadores expresaron haber informado a sus vecinos de los resultados logrados. Para el caso de Nicaragua un 82% de los(as) experimentadores (as) compartieron el aprendizaje con sus vecinos, en Guatemala un 71% y en Costa Rica un 49% de los experimentadores(as) lo hicieron, (Cuadro 11).

Cuadro 11. Consideración sobre la diseminación de los aprendizajes en las fincas vecinas de los(as) experimentadores(as) locales en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación (Irradiación de la información a fincas vecinas)
Costa Rica	49%		Indicaron haber **comunicado a otros productores**

Nicaragua	82%	**67,3%**	**vecinos los resultados** de la validación en las parcelas.
Guatemala	71%		

Fuente: sondeo con los productores(as) experimentadores(as) participantes del proyecto 2010.

Se consultó a los(as) participantes cuánto tiempo más deberían seguir con las parcelas de prueba para consolidar los resultados y aprendizajes logrados hasta el final de 2010. En promedio para los tres países un 86% de los productores comentaron que necesitarían al menos 1,6 (promedio por finca) años más conduciendo las parcelas de validación, (Cuadro 12).

Cuadro 12. Consideraciones de los participantes sobre cuánto tiempo más es necesario para consolidar los resultados logrados hasta 2010 en las parcelas de validación en los tres países. CATIE-CAFNET-CIRAD.

País	% Finqueros	% Promedio	Criterio de evaluación
Costa Rica	88%	**86%**	Indicaron que **se necesitaría al menos 1,6 años (promedio por finca) más** para consolidar los resultados en las parcelas de validación.
Nicaragua	91%		
Guatemala	79%		

Fuente: sondeo con los productores(as) experimentadores(as) participantes del proyecto 2010.

Lecciones aprendidas con la Validación Participativa de Prácticas Agroforestales:

1. *Las parcelas de validación representaron importante espacio de aprendizaje y conjuntamente con las capacitaciones aplicadas enlazaron adecuadamente teoría y práctica relacionadas a los diferentes enfoques de manejo agroforestal sostenible ;*

2. *La mayoría de los(as) productores(as) tuvieron resultados positivos en los cafetales con las innovaciones probadas en parcelas de validación indicando que pueden seguir mejorando, desde los distintos manejos y eco-certificaciones, los resultados de las prácticas agroforestales sostenibles;*

3. *La metodología de parcelas de aprendizaje participativa, a igual que en otras experiencias de proyectos de CATIE, se consolida como una opción para contribuir tanto para un aprendizaje integral como para generar cambios positivos en las fincas cafetaleras.*

Tiempo equipo involucrado componente de Validación de Prácticas Agroforestales Sostenible-CATIE-CAFNET-CIRAD

Concepto	Costa Rica	Nicaragua	Guatemala
Equipo Investigadores principales	5 meses + 20 días	1 mes + 3 días	4 meses + 5 días
Equipo técnico (Beatriz E.;Roberto J.; W.M.; Alma Q.; Rudi Del C.;	21 meses + 18 días	6 meses	16 meses

Equipo técnico de organizaciones colaboradoras	5 meses 28 días	5 meses	2 meses + 20 días
Pasante Eduardo Neves –USP-Brasil	7 meses		
Pasante Sonia Banessa-UNA-Honduras	3 meses		
Pasante Carlos Zapata-UNA-Honduras	3 meses		
Total	**47 meses**	**12 meses + 3 días**	**22 meses + 25 días**

7.Efecto de la sombra en plagas y enfermedades en Costa Rica (2008-2011)

Jacques Avelino
Elias de Melo Virginio Filho
Cipriano Rivera
Amada Olivas
Donal López
Esteban Brenes
Stefania Pinzón

Efectos de la sombra sobre roya del café (Hemileia vastatrix) con modificaciones de rendimiento y microclima

Los efectos de la sombra sobre la roya son controvertidos. Algunos autores mencionan que la sombra favorece la roya, mientras que otros mencionan lo contrario. La controversia podría deberse al hecho que la sombra tiene efectos antagónicos sobre la roya. Por un lado, la sombra reduce la carga fructífera, lo cual es desfavorable para el desarrollo de la roya, ya que existe una correlación positiva entre carga fructífera e intensidad de la epidemia. Por otro lado, la sombra modifica el microclima, y posiblemente proporcione condiciones más favorables para el desarrollo de la roya (temperatura y mojadura de la hoja especialmente). El balance entre estas dos vías de acción es incierto. En la naturaleza, los efectos de la sombra a través de la carga fructífera y a través del microclima no están separados. Por lo tanto, se ideó un experimento para separarlos.

El experimento se montó en junio del 2008 en los bordes del ensayo de sistemas agroforestales del CATIE, en Turrialba, Costa Rica, y se extendió hasta noviembre del 2009. El principio del experimento fue de volver independientes los factores carga fructífera y microclima. Para eso se usó una parcela de café que se dividió en dos. Una subparcela fue mantenida bajo sombra y la otra al sol. Se les aplicó a las dos subparcelas un tratamiento de regulación manual de la carga fructífera, obteniendo 4 niveles de carga fructífera: 0, 150, 250 y 500 nudos fructíferos por planta. Se tuvieron unas 10 plantas, o repeticiones, en promedio por nivel de carga fructífera en cada una de las dos condiciones de sombra. En cada subparcela, se monitoreó el avance de la enfermedad y se registró el microclima: la temperatura del aire y de la hoja, la humedad relativa, la mojadura de la hoja.

En los dos años del estudio se observó que a mayor carga fructífera, había mayor área bajo la curva de progreso de la roya, es decir mayor intensidad de la epidemia, lo cual era esperado. Dependiendo de los descriptores de la epidemia y de los años, se cuantificó una reducción de la incidencia de entre 6,4 % y 30,8 %, y de la severidad de entre 37,5 % y 66,1 %, con 0 nudo fructífero con respecto a 500. También se observó que, al homogeneizar la carga fructífera, se tenían mayores ataques en la parcela bajo sombra comparado con lo que se tenía al sol. Dependiendo de los descriptores de la epidemia y de los años, la incidencia se redujo de entre 3,3 % y 27,7 % en la parcela al sol con respecto a la parcela bajo sombra. Lo anterior indica que cuando la roya no alcanza niveles altos bajo sombra, es porque la sombra disminuye la carga fructífera, pero que a carga fructífera idéntica hay mejores condiciones para el desarrollo de la roya bajo sombra que al sol.

Al analizar las condiciones de microclima, se observaron efectivamente mejores condiciones microclimáticas para el desarrollo de la roya bajo sombra, especialmente durante el día, con menores variaciones de las temperaturas (especialmente menores máximas) y mayor frecuencia de mojadura. Al mediodía, en días sin lluvia, se registraron así temperaturas de la hoja en promedio de 34.3 °C al sol, mientras que bajo sombra sólo alcanzaron 28.6 °C. En días con lluvias mayores a 5 mm, al mediodía, se registró, en 2009, una frecuencia de mojadura de la hoja de 65.6 % bajo sombra mientras que sólo se obtuvo 34.1 % al sol

Este trabajo se condujo en el marco de la tesis de maestría de Donal Lopez Bravo.

Efectos de la sombra sobre la broca del café (Hypothenemus hampei) en Turrialba, Costa Rica

La información del efecto de la sombra sobre la broca es escasa y contradictoria, como en el caso de la roya. Pensamos que también podían existir efectos antagónicos de la sombra sobre la broca. La fenología bajo sombra podría ser menos favorable para la broca porque normalmente las floraciones suelen ser más agrupadas que al sol. Pero el microclima podría ser más favorable. Una mayor humedad podría incrementar la humedad de los frutos remanentes y permitir la reproducción de la broca en esos frutos durante más tiempo. La temperatura también podría ser más favorable para el desarrollo de la broca. Como para la roya, el balance de estos efectos es incierto y podría explicar las controversias.

Este trabajo se llevó a cabo de Febrero a Agosto del 2010 en el ensayo de sistemas agroforestales del CATIE, en Turrialba, Costa Rica, por lo tanto en una zona de baja altura. Utilizamos diferentes tratamientos de sombra y de manejo del ensayo. A lo largo del estudio, se muestrearon frutos verdes, maduros, y secos que se disectaron para evaluar las poblaciones de broca. También, seguimos la dinámica de infestación de frutos y se estudió paralelamente la dinámica de crecimiento de los frutos. El microclima se caracterizó en dos condiciones extremas de exposición a la luz: (i) plena exposición al sol y (ii) sombra densa proporcionada por dos especies de sombra: poró (*Erythrina poeppigiana*) y el cashá (*Abarema idiopoda*).

Encontramos que la sombra incrementa las poblaciones de broca dentro de los frutos. Por ejemplo, se encontró un promedio de 11.1 hembras vivas en frutos secos del arból bajo sombra regular de poró comparado con 4.0 hembras solamente a pleno sol, en ambos casos bajo condiciones de manejo convencional sin insecticida (Figura 1).

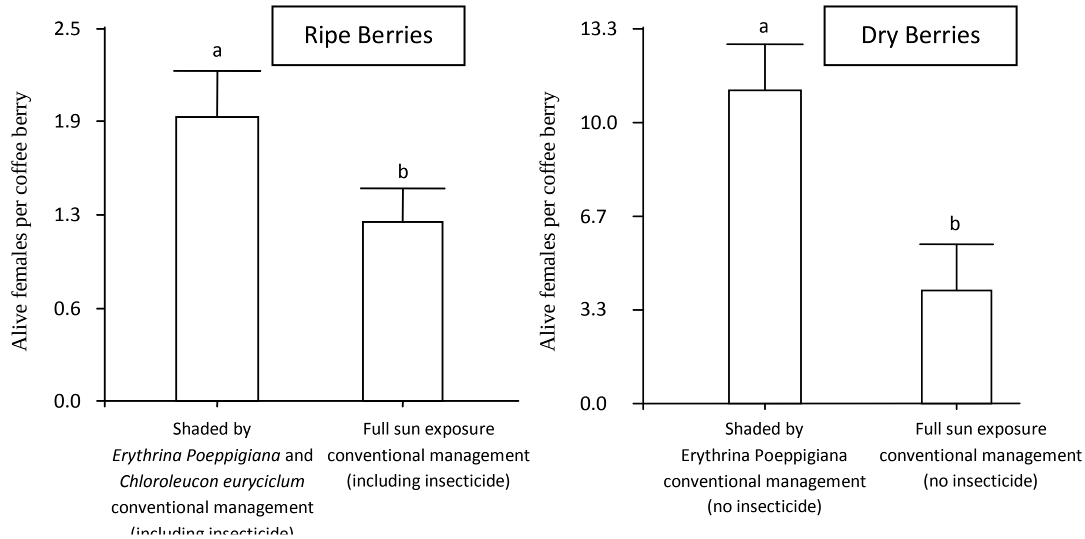


Figure 1 Effect of shade on the number of coffee berry borer females in ripe berries and dry berries of the coffee tree

Se verificó, al igual que con la roya, que las condiciones microclimáticas son mejores para la broca bajo sombra que a pleno sol. Se observó que bajo sombra densa de poró y cashá las temperaturas del aire siempre estaban más cerca de las temperaturas adecuadas para la reproducción de la broca. Al mediodía, en días sin lluvia, se registraron así temperaturas del aire en promedio de 33.4 °C al sol, mientras que bajo sombra densa sólo alcanzaron 29.5 °C. También observamos mejores condiciones de mojadura de los órganos y de humedad relativa. En días con lluvias mayores a 5 mm, al mediodía, se registró en promedio un valor de humedad relativa de 86 % bajo sombra, mientras que sólo se alcanzó 77 % al sol.

El estudio de la fenología trajo otros resultados. A plena exposición al sol, se observó una maduración adelantada de los frutos. Se verificó que estos frutos son mucho más atractivos para la broca que los frutos verdes, ya que tuvieron porcentajes de infestación tres veces superiores. Sin embargo, esto no condujo a mayores infestaciones al sol. En efecto, poco antes de la cosecha, se observó un porcentaje de infestación en los frutos pintones de 59 % en las parcelas con sombra densa, manejo convencional con insecticida, comparado con el 5 % observado al sol bajo las mismas condiciones de manejo. Sin embargo, se observó que la sombra sí reduce las infestaciones de broca en los manejos orgánicos, cuando se usa *Beauveria Bastiana*, posiblemente porque las condiciones de sombra proporcionan mejores condiciones para el desarrollo del hongo. Se tuvieron sólo 6 % de frutos pintones infestados con sombra densa, comparado con 18 % bajo sombra regular.

Lo anterior significa que si se tiene sombra densa es mejor usar *B. bassiana* para controlar la broca. Pero, si no se va a usar *B. bassiana*, es mejor reducir el porcentaje de sombra.

Este trabajo se condujo en el marco de la tesis de maestría de Esteban Sánchez.

Conclusión

Se concluye que hay efectos antagónicos de la sombra sobre la roya y la broca. La sombra reduce la infección por roya reduciendo la carga fructífera, pero provee mejores condiciones microclimáticas para la enfermedad, lo cual en condiciones de producción equivalente al sol y bajo sombra puede traducirse por mayores infecciones bajo sombra que al sol. La sombra favorece la broca, proporcionando mejores condiciones de microclima para el desarrollo del insecto, pero provee también mejores condiciones para el crecimiento de B. bassiana y reduce por este medio las infestaciones. Por lo tanto, no hay una respuesta sencilla sobre los efectos de la sombra, y la respuesta puede ser todavía más complicada si se considera la diversidad de condiciones en las que el café se cultiva. Las respuestas posiblemente dependan mucho de esas condiciones. Para cada condición hay seguramente un manejo específico de la sombra por definir.

Concepto	Efecto de la sombra en plagas y enfermedades en Costa Rica (2008-2011)
Investigadores: Jacques Avelino Elias de Melo	 10 meses 1,5 meses
Técnicos: Cipriano Rivera Amada Olivas	 1 meses 3 meses
Estudiantes: Donal Lopez Esteban Brenes Stefania Pinzón	 21 meses 16 meses 6 meses
Total	58,5 meses

8.Efecto del paisaje sobre las plagas y enfermedades del café en Costa Rica (2008-2011)

Jacques Avelino
Fabrice de Clerck
Cipriano Rivera
Amada Olivas
Ali Romero

El paisaje puede proporcionar condiciones y recursos para la supervivencia de los organismos nocivos y de los organismos benéficos, y también facilitar o impedir sus desplazamientos. Los movimientos se dan cuando hay conectividad en el paisaje. Los factores climáticos también pueden modificarse de acuerdo a la naturaleza del paisaje. Las temperaturas que imperan en una finca pueden ser por ejemplo muy diferentes de acuerdo a la naturaleza del paisaje que la rodea. También el viento el cual contribuye al movimiento de los organismos puede ser muy diferente. Los efectos conocidos del paisaje sobre las plagas y enfermedades nos han llevado a hacernos preguntas sobre como el paisaje afecta las plagas y enfermedades del café. A continuación, se darán a conocer los resultados de tres estudios sobre este tema.

Relaciones entre el contexto paisajístico y los ataques de la roya (Hemileia vastarix), la broca (Hypothenemus hampei) y los nematodos agalladores (Meloidogyne exigua) en Costa Rica

Para estudiar las relaciones que existen entre estos tres organismos y el paisaje, se llevó a cabo un estudio en 29 parcelas de café en la región de Turrialba en 2009. En cada parcela de café se evaluaron los ataques de broca, roya y nematodos y se caracterizó el paisaje a su alrededor hasta una distancia de 1500 m. Esta caracterización se hizo a partir de fotos áreas y corroboraciones de campo. Después, se calcularon las correlaciones que existen entre la incidencia de las plagas y enfermedades del estudio y varias métricas de paisaje, especialmente los porcentajes del área ocupados por los principales usos del suelo, a diferentes escalas espaciales (distancias de las parcelas evaluadas). Al final, se obtuvo una serie de coeficientes de correlaciones en función de la escala espacial.

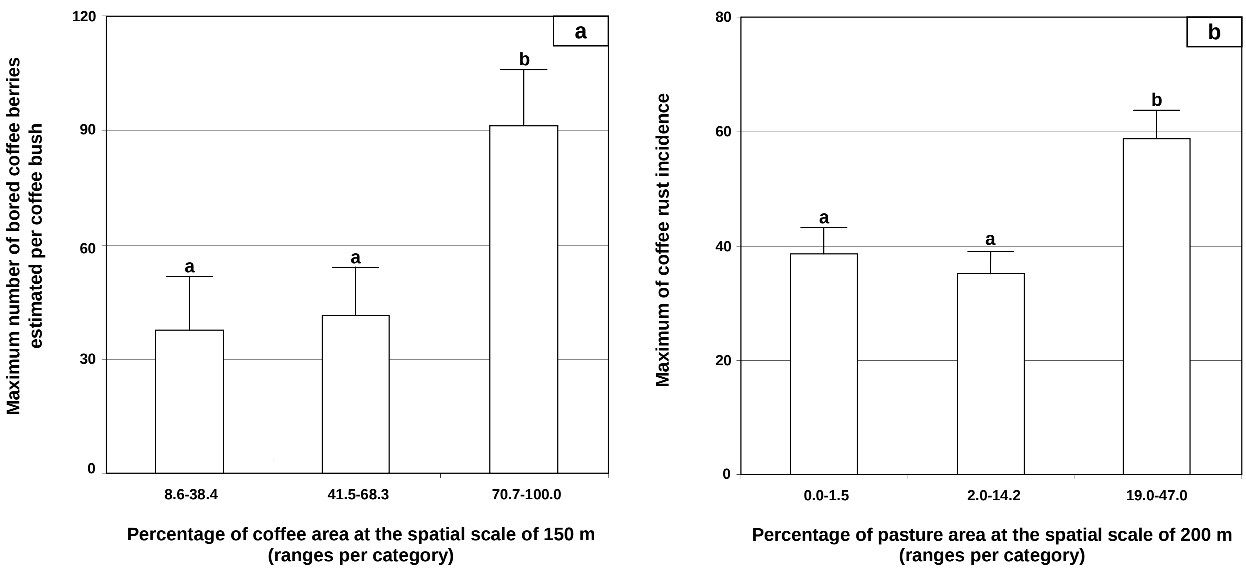


Figure 2 Landscape context effect on coffee berry borer (a) and coffee rust incidence (b); adjusted means corrected by the effects of elevation and number of bored coffee berries remaining in the coffee bush after harvest (a), and of soil pH, percentage of shade cover, number of fruiting nodes per coffee bush and annual number of fertilizer applications (b). Categories with different letters are different according to Bonferroni test at *P*=0.05.

Se observaron múltiples correlaciones positivas entre el porcentaje del área con café a diferentes escalas espaciales con los ataques de broca, con un pico significativo a 150 m. Para la roya, se observaron múltiples correlaciones positivas entre el porcentaje del área con pasto y los ataques de roya con un pico a 200 m. Esto significa que sí hay relaciones entre paisaje y los ataques de roya y broca, lo cual es muy novedoso. Para la broca, se piensa que este insecto, muy específico del café, incrementa su nivel de supervivencia cuando hay mayor concentración de áreas de café. Eso es especialmente importante en las épocas del año en las que las cerezas de café son escasas. El pico de 150 m, representaría la distancia que ese organismo puede explorar. Para la roya, se piensa que la alternancia de espacios abiertos (como el pasto) y de sistemas agroforestales a base de café, provoca turbulencias, incrementa la liberación de las esporas en grupos, y su depositación cerca de la fuente, incrementando así los ataques. No se observaron relaciones con los nematodos. Como organismos casi inmóviles, éstos son por lo tanto poco sujetos a una influencia del paisaje sobre su movimiento.

Se verificó que estas correlaciones reflejan un verdadero efecto del paisaje. Se corrieron dos análisis de covarianza, corrigiendo la variabilidad con los predictores más importantes de la broca y de la roya a escala de la planta y de la parcela, que se usaron como covariables. Aún corrigiendo la variabilidad por esas covariables (que fueron muy significativas y que se correlacionaron con las variables estudiadas en el sentido esperado), se mantuvo el efecto del paisaje, sugiriendo un efecto real del paisaje (Figura 2).

Este trabajo se desarrolló en el marco de las tesis de bachiller de Hector Cruz y de maestría de Alí Romero.

Efectos del micropaisaje sobre la dispersión de la broca (Hypothenemus hampei) en Turrialba, Costa Rica

Con el fin de comprobar que el paisaje afecta la dispersión de la broca, montamos un trabajo en 6 parcelas de café aisladas, bordeadas por dos usos de suelo, entre bosque, caña y pasto. Al estar aisladas, esto significa que la principal fuente de broca era esas mismas parcelas. Se instalaron transectos de trampas Brocap que comportan difusores de un atrayente alcohólico y que permiten capturar la broca, para estudiar como la broca se dispersa desde los cafetales hacia fuera de acuerdo al uso del suelo. La primera trampa del transecto se ubicó 30 m adentro del cafetal y la última a 140 m del cafetal. Entre trampas había 10 m. El trabajo se llevó por 120 días en la época de vuelo de la broca en el primer semestre del 2009.

De acuerdo a nuestros resultados, la broca se dispersa poco fuera del cafetal, ya que más del 96% de las brocas se capturaron en las trampas dentro del café, y apenas el 4 % fuera del cafetal. Lo que ayuda a entender los resultados del estudio anterior. A la broca no le parece gustar la fragmentación de los cafetales. A pesar de esta poca dispersión fuera del café, sí se logró capturar algunos individuos a las distancias más alejadas del cafetal (140 m), lo cual también parece coincidir con los resultados del estudio anterior: es muy probable que haya muy pocos individuos capaces de extenderse a más de 150 m. Se logró también evidenciar diferencias de fricciones entre los diferentes usos. Se capturó menos broca en los bosques que en el pasto, y menos en pasto que en la caña. Esto permite pensar que el bosque es el uso que rompe más la conectividad para la broca.

Este trabajo se llevó a cabo en el marco de la tesis de maestría de Amada Olivas.

Distribución especial de la broca (Hypothenemus hampei) en un paisaje complejo de Jicotea, Turrialba, Costa Rica

Se montó un trabajo de distribución espacial de la broca en un paisaje complejo para comprobar los efectos del paisaje sobre la broca, especialmente de los parches sembrados de bosque, caña y pasto. En este paisaje de 25 ha se instaló una red de trampas Brocap separadas por 50 m y otras trampas separadas por 20 m, para un total de 153 trampas. El trabajo se llevó a cabo por 168 días durante la época de vuelo de la broca en el primer semestre del 2010.

Este trabajo confirmó la alta fricción al movimiento de la broca de las áreas boscosas. En cambio, se observaron zonas de aparente conectividad constituidas por supuesto por el café, pero también por las zonas de caña y pasto, confirmando así los resultados anteriores.

Conclusiones

Se puede concluir que sí hay una relación entre el paisaje y los ataques de roya y broca, que el efecto sobre la broca es seguramente a través de su dispersión con efectos de barrera que se oponen a su movimiento, especialmente para el caso del bosque. Quedaría por confirmar que la broca no puede ser transportada por el viento por encima del bosque. Todavía no se tienen resultados sobre el mecanismo de acción del paisaje sobre la roya. Este podría afectar la dispersión de la roya pero también el proceso de infección por variaciones del microclima. Finalmente, nuestros resultados sugieren que podría ser importante integrar el paisaje en las estrategias de control de las plagas y enfermedades del café. En realidad, las prácticas más eficientes son seguramente las que se establecen a nivel de la parcela, pero a través el manejo del paisaje, posiblemente se logren mejores resultados especialmente cuando hay efectos de barrera que impiden reinfestaciones.

Concepto	Efectos del paisaje sobre las plagas y enfermedades en Costa Rica (2008-2011)
Investigadores: Jacques Avelino Fabrice de Clerck	 10 meses 5 meses
Técnicos: Cipriano Rivera Amada Olivas	 15 meses 9 meses
Estudiantes: Ali Romero Amada Olivas Hector Cruz	 17 meses 15 meses 6 meses
Total	77 meses

<u>Publicaciones:</u>

Cápitulos de libro

Avelino J., ten Hoopen M., DeClerk F. 2011. Ecological Mechanisms for Pest and Disease Control in Coffee and Cacao Agroecosystems of the Neotropics. In: Ecosystem Services from Agriculture and Agroforestry. Measurement and Payment. Edited By Bruno Rapidel, Fabrice DeClerck, Jean-Francois Le Coq and John Beer. Earthscan. p. 91-118.

Comunicaciones

Avelino J., DeClerck F., Olivas A.P., Rivera C., Cruz H., Romero A. 2010. Landscape context and movement of coffee pests. In: Agrobiodiversity in Mesoamerica: from genes to landscape: VI Henri A. Wallace Inter-American Scientific Conference Series, Turrialba, Costa Rica, September 20-24, 2010.

Olivas A.P., Rivera C., Dufour B., Hidalgo E., DeClerck F., Avelino J. 2010. Micro-landscape context effects on the dispersal of coffee berry borer (Hypothenemus hampei) in Costa Rica. In: Agrobiodiversity in Mesoamerica: from genes to landscape: VI Henri A. Wallace Inter-American Scientific Conference Series, Turrialba, Costa Rica, September 20-24, 2010.

Olivas A.P., Rivera C., Dufour B., Hidalgo E., DeClerck F., Avelino J. 2010. Micro-landscape context effects on the dispersal of coffee berry borer (Hypothenemus hampei) in Costa Rica. In: 23rd International Conference on Coffee Science, 3-8 October 2010, Bali, Indonesia.

Romero A., Cruz H., De Melo E., DeClerck F., Avelino J. 2010. Relationships between landscape context and coffee rust (Hemileia vastatrix), coffee berry borer (Hypothenemus hampei) and the rootknot nematodes Meloidogyne spp. in Costa Rica. In: Agrobiodiversity in Mesoamerica: from genes to landscape: VI Henri A. Wallace Inter-American Scientific Conference Series, Turrialba, Costa Rica, September 20-24, 2010.

Romero A., Cruz H., De Melo E., DeClerck F., Avelino J. 2010. Landscape context and plot incidence of coffee rust (Hemileia vastatrix), coffee berry borer (Hypothenemus hampei) and the Root-knot nematodes Meloidogyne spp. in Costa Rica. In: 23rd International Conference on Coffee Science, 3-8 October 2010, Bali, Indonesia.

Memorias

Cruz Cuellar H.F. 2010. Caracterización e impacto del contexto paisajístico y su posible influencia sobre los niveles de Broca Hypothenemus hampei (Ferrari), en la Provincia de Cartago (Costa Rica); Memoria de Bachiller. Universidad del Tolima, Colombia, Facultad de Ciencias. 67 p.

López Bravo D.L. 2010. Efecto de la carga fructífera sobre la roya (Hemileia vastatrix) del café, bajo condiciones microclimáticas de sol y sombra, en Turrialba, Costa Rica; Memoria de Master, CATIE, Costa Rica, 99 p.

Olivas A.P. 2010. Efecto del uso del suelo adyacente al cafetal sobre la dispersión y dinámica poblacional de la broca Hypothenemus hampei Ferrari y la abundancia de enemigos naturales en el cantón de Turrialba, Costa Rica; Memoria de Master, CATIE, Costa Rica, 140 p.

Romero Gurdián A. 2010. Efecto de los sistemas agroforestales del café y del contexto del paisaje sobre la roya, (Hemileia vastatrix), broca (Hypothenemus hampei, Ferrari) y los nematodos Meloidogyne spp.), con diferentes certificaciones en la provincia de Cartago Costa Rica; Memoria de Master, CATIE, Costa Rica, 102 p.

Sánchez, E. 2011. Efecto de la sombra y del manejo del café sobre la dinámica poblacional de (*Hypothenemus hampei* Ferrari) en frutos

9.Valoración económica de servicios ambientales

9.1.Pago de Servicios Ecosistémicos para Sistemas Agroforestales Establecidos - Costa Rica

Elias de Melo Virginio Filho-CATIE
Sergio Abarca-INTA
Jorge Cabrera Medaglia-UCR
Carlos Jones León-FUNCAFOR
Ronald Peters-ICAFE
Mario Arroyo-ICAFE
José Guzmán-ICAFE
Aarón Fernández-ICAFE

En una alianza conformada por La Fundación Café Forestal- FUNCAFOR del grupo de cooperativas de COOCAFE, miembros del equipo CATIE-CAFNET-CIRAD, del INTA, Instituto del Café de Costa Rica- ICAFE y el Fondo de Financiamiento Forestal-FONAFIFO se ha desarrollado en los últimos 4 años una intensa reflexión y promoción del fortalecimiento del esquema nacional de Pago por Servicios Ambientales a partir de la generación de una nueva categoría que reconozca los cafetales arbolados establecidos. Como logros de este esfuerzo se ha generado diferentes resultados, a saber:

1) Estudio realizado por Virginio Filho y Abarca (2008) evidencia el potencial de los cafetales para servicios ecosistémicos, y en particular almacenamiento de carbono, en el ámbito del sector cafetalero costarricense;

2) Establecimiento de convenio en mayo del 2009 entre CATIE-ICAFE-FUNCAFOR-INTA para presentación de una propuesta técnica y estudio de la viabilidad legal para el establecimiento de una nueva categoría de PSA para sistemas agroforestales con café establecidos. Se consolida en diferentes foros e instancias la viabilidad técnica y legal de la propuesta;

3) En reunión en mayo de 2011 la Junta Directiva de FONAFIFO, con la participación de las dos vice-ministras del MAG, vice-ministra de MINAET, presidente del ICAFE, representantes del INTA y de la FUNCAFOR acuerdan la firma de convenio para la creación de la nueva categoría de PSA. El convenio será firmado por ICAFE-FONAFIFO-FUNCAFOR-MAG-INTA y CATIE;

4) El 5 de junio en la prensa nacional FONAFIFO hace público la reserva de un fondo semilla para la nueva categoría y en seguida el ICAFE en junta directiva decide lo mismo, de manera que el convenio a ser firmado ya cuenta con fondos iniciales para el desarrollo de una fase piloto. Se espera desarrollar y validar el mecanismo para luego ampliarlo a partir de aportaciones de recursos de diferentes fuentes adicionales a FONAFICO y ICAFE.

Lecciones aprendidas en la promoción del PSA- para SAF Café Establecido (Virginio Filho y Abarca 2008)

1. *“El conocimiento e información disponible confirma el potencial de los sistemas agroforestales bien manejados para cumplir con la lista de servicios ecosistémicos definidos internacionalmente. Particularmente la contribución en la fijación y almacenamiento de CO2 ubica a los SAF en café en posición de destaque. Están dados los elementos para el desarrollo de métodos que permitan la planificación, ejecución y monitoreo de programas de PSA en SAF.”*
2. *“El fortalecimiento de los Programas de PSA es tarea compleja que requiere un seguimiento constante en particular coordinado con las instancias… y actores que define y ejecutan políticas en esta área.”*
3. *“Los escenarios de mercados y espacios institucionales potenciales para la conformación de los fondos de financiamiento presentados y discutidos en el presente estudio (MDL, Voluntario, FONAFIFO, Sellos e iniciativas unilaterales de incentivo) deben ser considerados complementares entre si, sin embargo requieren estratégicas especificas que permitan ir promoviendo avances. La complejidad de la negociación internacional ubica el mecanismo MDL como el más complejo y de difícil respuesta a corto y mediano plazo.”*
4. *“El esquema FONAFIFO está dado para que se fortalezca su papel hacia el sector cafetalero y hay que consolidar los vínculos con una incidencia política que permita mayor protagonismo de COOCAFE y del sector cafetalero. Por un lado se debe maximizar todos los tipos de PSA (protección bosques, reforestación y SAF) para las fincas cafetaleras y por otro ir promoviendo la idea de que hay que mejorar el sistema de incentivo para los SAF con café.”*

9.2.Impacto de las certificaciones en Costa Rica, Nicaragua y Guatemala

Gabriela Soto
Jeremy Haggar

Se estudió el impacto económico, social y ambiental de las certificaciones Rainforest Alliance, Starbucks CAFÉ Practices, Utz Certified, Orgánico y Comercio Justo en café en Guatemala, Nicaragua y Costa Rica. Para esto se utilizó el cuestionario COSA® que fue adaptado a las condiciones locales de cada país. Se seleccionaron encuestadores con amplio conocimiento en café e idealmente en certificaciones de café, que fueron capacitados en la metodología propuesta para hacer las encuestas. En Guatemala se trabajó con Técnicos de ANACAFE, en Nicaragua con técnicos del proyecto Innovaciones y en Costa Rica fueron estudiantes y técnicos de las cooperativas. Se muestrearon 40 productores por sello y en cada país 80 productores convencionales para un total de 840 encuestas. Los resultados preliminares muestran que tanto en Guatemala como en Costa Rica el productor no percibe un fuerte diferencial de precios por estar certificado en la mayoría de los sellos. Los productores orgánicos en general muestran una baja productividad que se traduce en una menor rentabilidad a pesar del sobreprecio.

9.3.Plataforma de certificaciones

Gabriela Soto

Se promueve el desarrollo de una plataforma de agencias de certificación como una estrategia para reducir los costos de acceso a la certificación y fortalecer la consistencia de las normativas y garantizar la provisión de servicios ecosistémicos. Se realizaron talleres, inicialmente para definir las áreas de interés común de los diferentes sellos, y para transmitir los resultados y la investigación en curso que el proyecto quería realizar, así como definir en forma conjunta acciones futuras. Sin embargo, no obtuvimos respuestas positivas de todos los sellos. En algunos casos los técnicos a cargo mucho interés (Rainforest Alliance, Nespresso y orgánico), pero en los otros sellos, sintieron que este tipo de espacio ponía en riesgo las diferencias que distinguen a cada una de las agencias, por lo que decidieron no participar en este proceso. En este momento, colaboración entre agencias parece posible únicamente a nivel de campo, en la arena comercial y política.

9.4.Desarrollo de modelo de cadenas de valor a través de la evaluación de alianzas de productores y comercializadoras frente a limitantes.

9.4.1.El caso de Costa Rica

Guy Faure-CIRAD
Jena François Le Coq- CIRAD
Gabriela Soto- CATIE

El análisis de la organización de los productores en Costa Rica fue desarrollado desde 2008 (Faure y Le Coq, 2009). Revela la importancia de las cooperativas y de las organizaciones de productores en la toma de decisión del proceso de la certificación para los pequeños productores, especialmente su papel en la reducción de costos de acceso y proporcionar los servicios que facilitan el acceso de los productores a la certificación. También demostramos que las OP (organizaciones de productores) tienen diversas estrategias de múltiple certificaciones para responder a la demanda de mercado según la calidad del café que manejan, su volumen de producción y su capacidad de poner en la práctica trazabilidad. Debido al hecho de que el premio vinculado a una certificación no sea generalmente lo suficiente para compensar los costos de la certificación, la producción de calidad del café sigue siendo el conductor principal de las estrategias de las OP´s para obtener un mejor precio. Por otra parte, se evidencia diversa estrategia de la distribución del premio a los miembros basado en los valores las OP´s (igualdad entre los miembros o reconocimiento de esfuerzos individuales) o de las capacidades de manejar la trazabilidad.

Estos resultados se han presentado tanto en artículos y comunicaciones específicas en talleres internacionales, y en eventos de difusión en el área de CAFNET.

Se ha desarrollado para Costa Rica una tesis de maestría que evidencia la diferencia en la distribución de los premios a lo largo de la cadena de valor del café.

9.4.2. El caso de Guatemala

Jean Fronçois Le Coq
Henry Hocde

Una primera misión se ha ejecutado en la región piloto de la RBSM que identificaba el contexto de las organizaciones locales, su situación y estrategia así como la problemática del manejo de la cuenca y la opción para el PSA hídrico (Hocde, 2009). Luego, de un análisis preliminar de la cadena guatemalteca del café se ha identificado un embotellamiento principal del desarrollo de la cadena y de las certificaciones (Le Coq, 2010). Más específicamente, en el sitio de la investigación de CAFNET de San Agustín (RBSM), se hizo un taller participativo realizado con la ayuda de "defensores de la naturaleza" con la participación de organizaciones y a las instituciones locales del café. Durante este taller, se mapeo la cadena local del café con los actores, el mayor problema identificado y la acción estratégica operacional definida fue por ejemplo el desarrollo de una marca local para el café del RSBM que permite una mejor valorización del los servicios ecosistémicos proporcionan los productores del café de la región, así como la ayuda del proyecto al proceso de la negociación entre la organización de productores del café y las agencias locales de certificación para facilitar la certificación orgánica. Finalmente, se indicó el mandato para que en el futuro se investigue la cadena de valor y el desarrollo de la certificación en Guatemala. La coordinación de CAFNET en Guatemala contrató a una consultora para el análisis del desarrollo de la certificación en el sector café (Yaniris Munoz, 2010).

9.4.3.El caso de Nicaragua

Henry Hocde-CIRAD
Jean François Le Coq-CIRAD

Se realizó una misión conjunta a Nicaragua en marzo de 2010. Tuvo como objetivo analizar del movimiento cooperativo del café y de la cadena en Nicaragua. Un dinamismo impresionante de cooperativas locales ha sido un punto culminante (Hocde y Le Coq, 2010). El desarrollo del movimiento cooperativo durante los últimos 5 años se ha basado en un proceso de la profesionalización de las cooperativas (manejo técnico y gerencial) que ha permitido un aumento rápido de la calidad del café junto con el desarrollo de la certificación del comercio justo y orgánico. Estas mejoras han sido valoradas por el mercado, y Nicaragua que fue afectada tradicionalmente por un diferencial negativo está disfrutando recientemente de un diferencial positivo en mercado internacional del café.

9.4.4.Análisis y actividades transnacionales

Jean François Le Coq-CIRAD
Gabriela Soto-CATIE
Guy Faure-CIRAD
Hanry Hocde-CIRAD

Las varias actividades desarrolladas en este componente permitieron a los participantes organizar un taller regional para las organizaciones de productores. El proceso de la preparación de este taller había sido iniciado especialmente con COOCAFE y su Fundación Café Forestal (consorcio de las cooperativas que tienen como objetivo promover comercio justo y exportación de café) el ICAFE (Instituto del Café de Costa Rica) pero también con organizaciones de productores y las instituciones en Guatemala y Nicaragua. El taller se realizó en octubre de 2010 en Costa Rica con alrededor de 50 participantes (la mitad representantes de las OP`s, y la otra mitad de ONG`s o agencias de la certificación, representantes de agencias públicas e investigadores). Este taller tuvo como objetivo divulgar los resultados del análisis de las organizaciones de productores y los procesos de la certificación realizados dentro del proyecto así como la facilitación de un análisis anticipado con las organizaciones para diseñar estrategias hacia la certificación del café para hacer frente de una mejor manera a los cambios de clima y demandas del mercado (Soto y otros, 2011). El taller final de CAFNET realizado en CATIE en mayo de 2011 fue otra oportunidad para presentar y diseminar los resultados de los estudios entre las OP`s, los técnicos y los investigadores. Medio día fue dedicado a este asunto (las cooperativas y las certificaciones).

El análisis de la dinámica de la certificación del café y de la disposición de servicios ecosistémicos en America Central se ha desarrollado (Soto y Le Coq, 2011). El análisis comparativo transnacional se ha iniciado, especialmente entre Costa Rica y Kenia que posibilitó la elaboración de 2 paneles de comunicaciones que ha sido aceptado para los talleres de ASIC en octubre de 2010 (Le Coq y otros, 2010; Pinard y otros 2010).

Concepto	Organización de productores	Cadena de valor	Certificación	PSA SAFCafé- Costa Rica
Equipo de investigadores	80 + 30 días (JF CR N G) Guy CR = 32 días con 3 misiones para Costa Rica (2008, 2010, 2011) Henry N	JF (15d CR+15d G +15d N + 15 d valo = 60)	2días Jeremy :	42 días Elias de Melo
Equipo técnico	10 días	30 días	8 días	5 días
Equipo de colabores	6 meses (Jorge) + 6 meses (Liliana) + 6 meses (Cesar) + 6 meses (Quispe)	5 meses Guate (estudio sellos)	60	50 días FUNCAFOR (Carlos Jones) 40 días INTA (Sergio Abarca). 40 días ICAFE 20 días Jorge Cabrera
Total (meses)	29,1	8	2,33	6,6

10.Los sistemas agroforestales de café en el contexto del paisaje

Introducción

Hasta ahora, la mayor parte del enfoque sobre certificación del café se ha centrado a escala de parcela: ¿cuál es la densidad y composición de árboles que debe mantenerse, cuánta sombra se permite y cuál es el impacto de dicha sombra en los servicios de conservación y producción a escala de la explotación agrícola? Mucho menos abundantes son los estudios que enfocan la manera en que la distribución espacial de los árboles en las fincas afecta la capacidad de las mismas para garantizar la provisión de servicios ecosistémicos, aparte de los estudios de polinizadores que analizan el papel de los bosques circundantes en poblaciones apícolas. Además, son muy pocos los estudios que hacen referencia a cuál es la función de los sistemas agroforestales de café a escala de paisaje y sobre cómo impacta el suministro de servicios ecosistémicos la ubicación de un cafetal en una cuenca. El proyecto CAFNET ha realizado varias contribuciones importantes sobre este tema, que incluyen estudios sobre recuento de agua, carbono y suelos en los cafetales dirigidos por Roupsard, y estudios sobre la composición del paisaje agrícola, micropaisaje y macropaisaje en la propagación de la broca. Estos resultados se publicaron en otro sitio y no los repetiremos en este informe. En su lugar, nos centramos en dos estudios. El primero, titulado "Puentes y barreras" complementa el trabajo realizado por Avelino y DeClerck sobre la distribución espacial de la broca y el trabajo sobre la conservación de aves y mamíferos conducido por DeClerck, que analiza de qué forma contribuye la ubicación de las parcelas de café a escala de explotación agrícola (±1000 ha) en la conectividad para la biodiversidad silvestre a escala de paisaje, pero también como barrera contra la propagación de las plagas del café —una situación de mutuo beneficio potencial para la producción cafetalera y la conservación de la biodiversidad. El segundo estudio, realizado por Estrada Carmona, analiza la forma en que la modelación del paisaje permite identificar porciones de paisaje con deficiencias críticas importantes para asegurar la conectividad biológica o las zonas de concentración de erosión. La identificación de esas áreas permitirá determinar las secciones de paisaje donde debe promoverse la agroforestería, incluidos los sistemas agroforestales de café, para garantizar la prestación de servicios ecosistémicos.

En ambos estudios, nos concentramos en el Corredor Biológico Volcánica Central Talamanca (Figura 1). A diferencia del concepto estrictamente ecológico de corredores (franjas lineales de vegetación que conectan hábitats naturales), los corredores biológicos costarricenses son grandes áreas de uso mixto. Por lo general, los corredores tienen un mayor propósito o fundamento socio-ecológico que el ecológico. En el caso del CBVCT, el objetivo del corredor es proveer conectividad biológica entre la cordillera volcánica central al norte y las montañas de Talamanca al sur en Costa Rica. El corredor mide 114.000 ha aproximadamente. En él predominan los bosques (51%) seguidos por pastizales (25%), café (8,5%), arbustos secundarios (6%) y caña de azúcar (4%). El corredor lo administra un comité directivo compuesto por ciudadanos particulares y por representantes de organismos centrales y organizaciones de la región tales como el Instituto Costarricense de Electricidad, la municipalidad de Turrialba, el CATIE, la Universidad de Costa Rica, el Ministerios de Agricultura y Ambiente y el Sistema Nacional de Áreas Protegidas, entre otros.

En el siguiente mapa se observa de qué forma el café desempeña una función primordial como tercer más importante uso del suelo pero que además ocupa las laderas centrales y superiores de la cuenca. Ambos estudios analizan el papel de los sistemas agroforestales de café en el suministro de servicios ecosistémicos. Señalamos que el café provee un contexto interesante de pago de servicios ecosistémicos porque se adapta con facilidad a los sistemas agroforestales de múltiples servicios. Segundo, la pérdida del costo de oportunidad en la transición del café de sol al de sombra es mucho menor que la pérdida del costo de oportunidad en la transición de la caña de azúcar o pastizales a bosque. De esta forma, los esquemas PSA ofrecen una interesante oportunidad para diseñar paisajes multifuncionales que mantengan los principios de conservación y de producción.

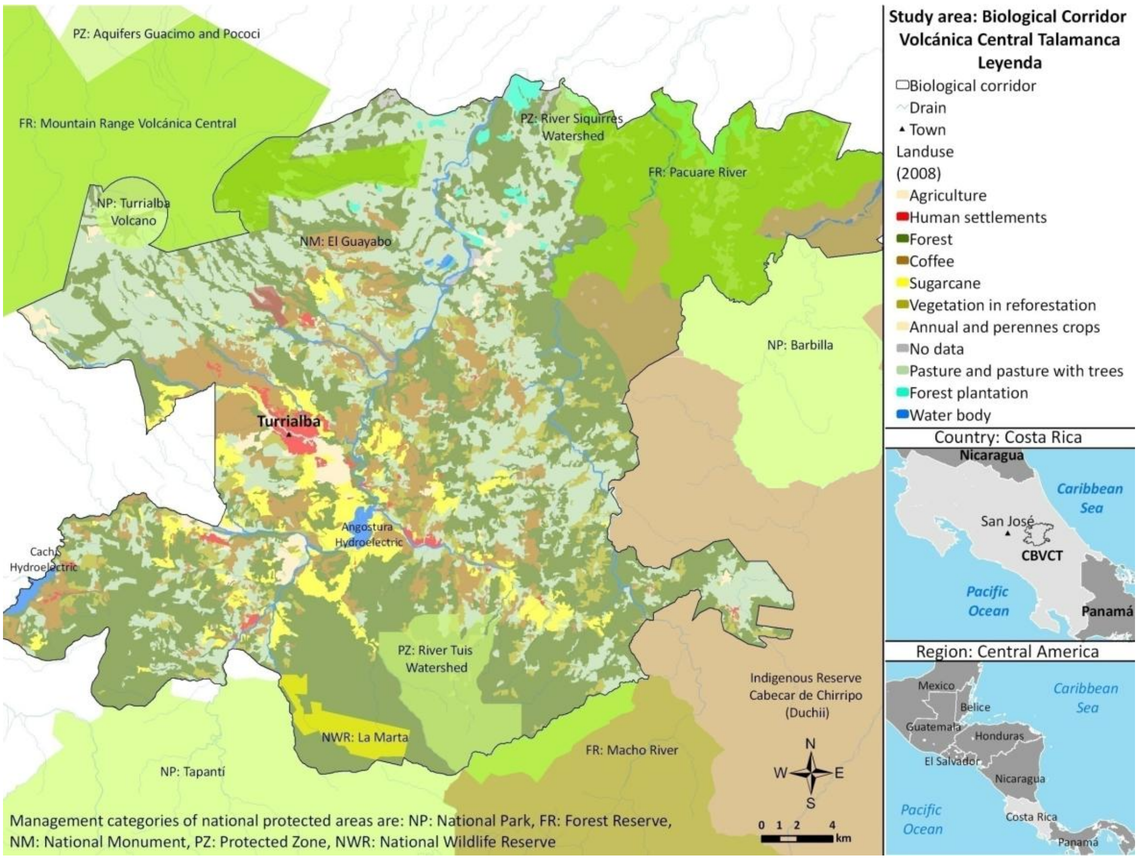


Figura 1: El Corredor Biológico Volcánica Central Talamanca (CBVCT) está ubicado en la parte central de la cordillera caribeña de Costa Rica Predominan los bosques, pastizales, café y caña de azúcar.

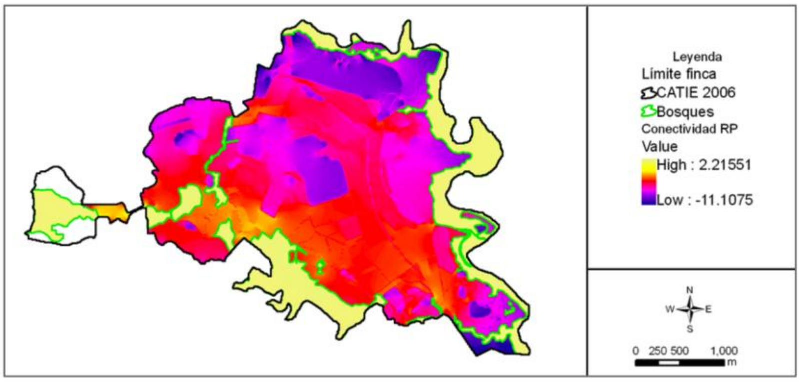
Puentes y barreras: la organización de la distribución espacial de árboles en cafetales y fincas ganaderas es un aporte para la conservación de la biodiversidad y el control de plagas

Participantes en la investigación: Fabrice DeClerck, Alejandra Martínez-Salinas, Natalia Estrada Carmona, Kelly Garbach, y Jacques Avelino

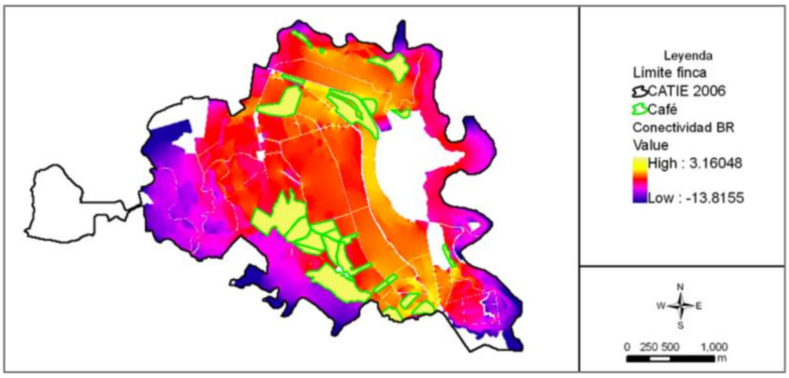
En la sección de biodiversidad de este informe, concluimos que los sistemas agroforestales de café son un buen hábitat para la diversidad de aves pero que no pueden conservar importantes especies que dependen del bosque. Además, concluimos que la mayor parte de los mamíferos evitan los sistemas agroforestales de café pero su diversidad y abundancia es bastante alta en las parcelas boscosas integradas o adyacentes a cafetales. Una observación final que se desprende del programa de monitoreo de aves es que las especies que dependen del bosque se encuentran en los sistemas agroforestales de café y de silvopastura pero esto es poco frecuente y parece coincidir con el final del período reproductivo cuando los machos jóvenes se dispersan en busca de nuevos territorios para el apareamiento. Este resultado indica que aunque estos sistemas agroforestales pueden ser un mal hábitat para aves que dependen del bosque, probablemente desempeñan un papel importante en la dispersión de especies y la dinámica de metapoblación.

Con esto en mente y con resultados del proyecto que indican que la propagación de la broca del café parece estar limitada por el fragmento de bosque, iniciamos el modelado del movimiento de aves y de la broca en la finca de 1000 ha del CATIE que posee vastas áreas de pasto y café. Para el modelado usamos *Circuitscape,* un programa que se basa en la teoría de gráficos como respaldo pero que añade la teoría general de circuitos eléctricos para producir modelos ráster del movimiento de especies y de ahí el nombre *Circuitscape.* La ventaja del modelo es que permite la representación gráfica del movimiento de especies a través de los paisajes e identifica la trayectoria del movimiento de especies, el aislamiento y los puntos de fijación.

La segunda ventaja del modelo es que funciona con pocos datos, principalmente con un mapa pixelado del uso de suelos recodificado de manera que cada uso de suelos represente la probabilidad de eventos de las especies deseadas. En nuestro caso, creamos dos matrices. La primera se creó con los datos de los proyectos de monitoreo de aves del CATIE basados en el mosquerito aceitunado, una especie dependiente del semi-bosque que se captura con frecuencia. La segunda matriz se desarrolló para la broca del café empleando los datos de la tesis de Amanda Olivas sobre la propagación de la broca en el café, pastos y caña de azúcar, es decir, los principales usos del suelo en la finca del CATIE y en CBVCT. El segundo archivo de datos requerido por el programa es una indicación de la ubicación de “puntos focales”. Las parcelas focales son el hábitat primario de las especies meta. Por ejemplo, en este estudio, el bosque comprende las parcelas focales del mosquiterito aceitunado y las plantaciones de café comprenden los puntos focales de la broca. Por lo tanto, el modelo ofrece un despliegue gráfico del movimiento entre las parcelas focales mediante el ploteo de las trayectorias de mayor conductividad o de menor resistencia (Figura 2).



Fuente: Finca de CATIE, 2006



Fuente: Finca de CATIE, 2006
Elaboró: Natalia Estrada C.

Figura 2: Modelos de conectividad para la finca del CATIE en Turrialba, Costa Rica. La figura en la parte inferior presenta los datos del mosquiterito aceitunado, como especie que interesa conservar y la figura en la parte superior presenta la información de la broca del café, una plaga agrícola. Las áreas amarillas con contorno verde representan parcelas focales o parcelas de café para la figura superior y bosques eh figura de abajo. Los colores indican las concentraciones de especies entre las parcelas focales donde el amarillo indica altas concentraciones y el color púrpura indica bajas concentraciones.

Los resultados del modelo muestran que la finca del CATIE, que tiene grandes caminos forestales al norte y al sur se encuentra muy fragmentada por el mosquiterito aceitunado. Parece darse un movimiento importante entre las parcelas focales ubicadas al sur de la finca pero no existen rutas claras entre las parcelas boscosas de mayor tamaño ubicadas al norte y al sur (Figura 2, mapa en la parte inferior). En contraposición, la conectividad de la broca del café parece ser alta con individuos que se desplazan libremente entre las plantaciones de café ubicadas al norte y al sur de la finca (Figura 2, mapa de arriba)

Los resultados de este ejercicio de modelación sugieren que es posible manejar el paisaje de la finca para incrementar el movimiento de especies que interesa conservar y que las intervenciones que se implementen para incrementar la conectividad pueden servir, asimismo, para limitar potencialmente la propagación de la broca del café. En teoría, limitar la propagación de la broca facilitaría su manejo mediante la reducción de los índices de inmigración. Esta teoría se está estudiando con mayor detalle en un nuevo proyecto en el que las plantas recién sembradas que no tienen broca se rodean con cercas vivas densas con el propósito de cuantificar el índice de inmigración en las plantaciones protegidas y en las que no lo están.

Uso de los modelos SIG para identificar el pago de servicios ecosistémicos en paisajes donde predomina el café

Participantes en la investigación: Natalia Estrada Carmona y Fabrice DeClerck

Costa Rica es pionera en el Pago de Servicios Ecosistémicos (PSE) y uno de los pocos países que cuenta con un fondo nacional para pagar cuatro servicios ecosistémicos: carbono, agua, biodiversidad y valor paisajístico. El fondo FONAFIFO recibe fuertes críticas a escala local, nacional e internacional porque no cumple con la demanda local de pago y porque existe poca evidencia de que los servicios que se pagan en realidad se reciben. El fondo se concentra básicamente en la conservación forestal, la reforestación que incluye las plantaciones forestales y los sistemas agroforestales. Los sistemas agroforestales reciben $1,30 por árbol plantado con un mínimo de 350 árboles y un máximo de 3.500.

No obstante, existen cuestionamientos importantes sobre la efectividad de estos pagos. Los pagos se hacen según el principio de que el primero en llegar es el primero en ser atendido y no apuntan a aquellos usos del suelo o posiciones de paisaje que son cruciales para garantizar la prestación del servicio deseado. En esta parte del proyecto CAFNET, modelamos dos servicios ecosistémicos importantes del Corredor Biológico Volcánica Central Talamanca (CBVCT): la reducción de la erosión y la conectividad biológica. Elegimos estos dos servicios por diversas razones. En primera instancia, se relacionan con los pagos de agua y biodiversidad del FONAFIFO. Segundo, son servicios prioritarios para el corredor donde se encuentra la Cuenca del río Reventazón. El control de la erosión de suelos es fundamental para reducir los costos administrativos de las seis plantas hidroeléctricas en la cuenca. Estas plantas producirán 37% de los requerimientos de energía de Costa Rica en el 2014. Segundo, como el área se identifica como corredor biológico a escala nacional, la conectividad biológica es en servicio ecosistémico esencial de la región. Tercero, dichos servicios dependen del uso de suelos, es decir, un sistema agroforestal de café tiene un gran potencial para proveer ambos servicios que el café de sol o que la caña de azúcar pero menos potencial que el bosque secundario. Por último, ambos servicios son espacialmente explícitos. Un sistema agroforestal de café rodeado de caña de azúcar tiene un menor potencial de conservación en términos de aprovisionamiento de hábitat y conectividad que el sistema agroforestal de café que se ubica adyacente a una parcela forestal. Un sistema agroforestal de café al pie de una ladera corta y poco profunda tiene menor potencial para reducir la erosión que los sistemas agroforestales de café ubicados en laderas hondas y empinadas en las partes más elevadas de la cuenca donde, por lo general, las partículas del suelo están desprendidas

Empleamos FUNCON (Conectividad Funcional) para modelar la conectividad a escala de paisaje para tres especies de aves: la reinita lados castaños, el sargento y el mosquiterito aceitunado. De las tres especies, el mosquiterito aceitunado es el que más depende del bosque. El modelo toma en cuenta las preferencias de hábitat de cada especie, la extensión del rango de búsqueda de recursos, el tamaño mínimo de la parcela permitido para cada especie y el comportamiento hacia los márgenes. El resultado final de este modelo es la identificación de las parcelas fundamentales para cada una de las especies. En la Figura 3 sólo presentamos los resultados del mosquiterito aceitunado. Este mapa es una representación de las regiones donde los pagos deben hacerse ya sea para establecer o mantener usos del suelo de alta densidad arbórea como bosques, plantaciones o sistemas agroforestales.

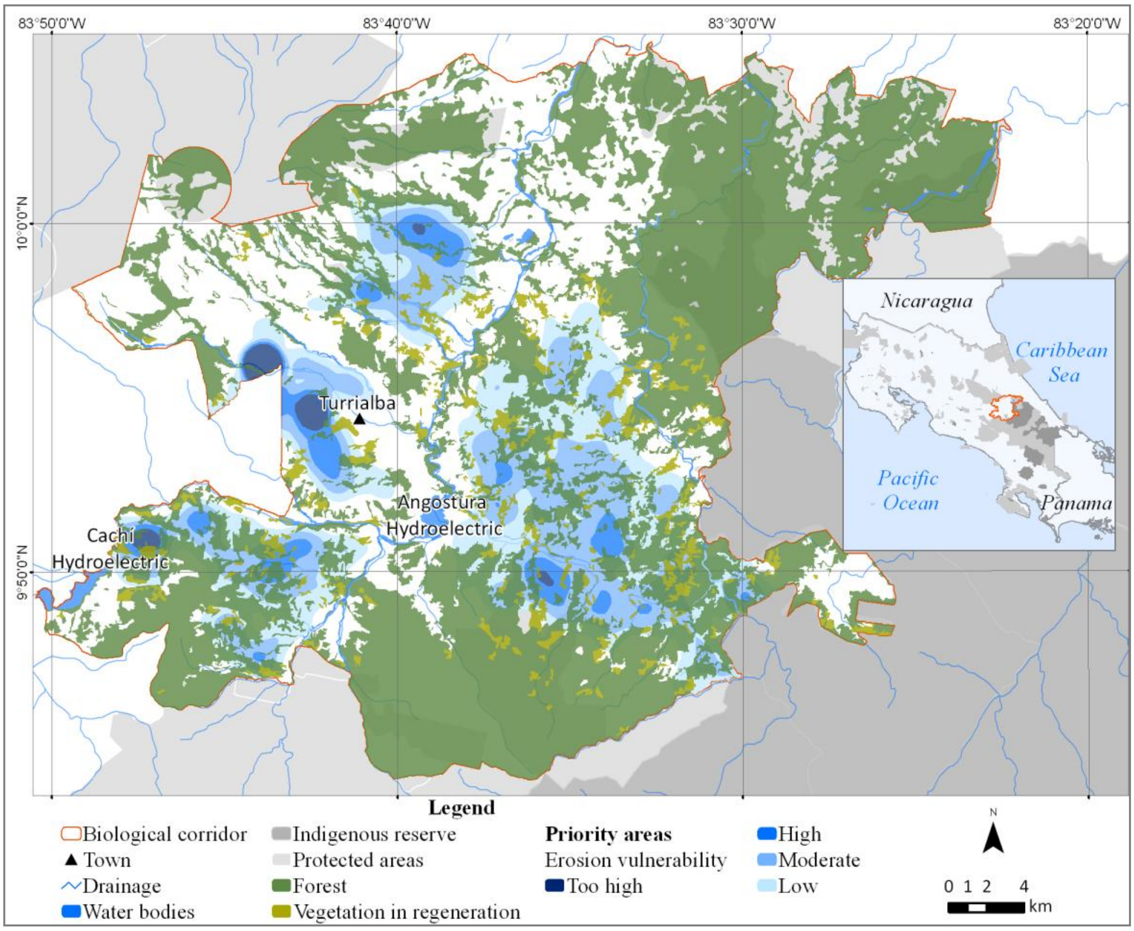


Figura 3: Mapa de las zonas de concentración de erosión derivadas de la Ecuación Universal Revisada de Pérdida de Suelo El modelo representa los procesos a escala de paisaje y excluye factores a escala de parcelas o caminos. A nuestro juicio, estas áreas deben identificarse potencialmente para el pago de servicios ecosistémicos orientados a reducir la sedimentación de las represas hidroeléctricas de la región: Cachí, Angostura y Reventazón (no aparecen en el mapa).

Utilizamos la Ecuación Universal Revisada de Pérdida de Suelo (EURPS) para modelar la erosión potencial en diferentes áreas del paisaje. Este modelo incluye el clima, la topografía y el uso de suelos como factores determinantes primarios de las regiones que generan erosión. El resultado final del modelo incluye un mapa de áreas con alta tendencia a la erosión. Este mapa es un indicador del hecho que debe pagarse por calidad del agua para reducir la sedimentación en la región específicamente en las tres represas ubicadas en la cuenca (Figura 4).

Por lo general, los esquemas PSE no tienen fondos suficientes para promover cambios importantes en el uso de suelos; por ejemplo, de caña de azúcar a bosques. Consideramos que parte de este problema se resolvería realizando pagos mucho más explícitos espacialmente. Parte de ello surge de la comprensión de cuáles usos del suelo son los más apropiados para el suministro de servicios ecosistémicos específicos y otra parte proviene de entender cuáles partes del paisaje son las más importantes para garantizar el suministro del servicio. Una solución potencial para acercar PSE a los esquemas de mercado que muestren con claridad la relación entre el pago realizado y los servicios recibidos. La segunda contribución puede encontrarse en los servicios de apilamiento, es decir, permitir que los agricultores vendan múltiples servicios a distintos compradores; en el caso del ejemplo anterior, que los agricultores reciben pago de las plantas hidroeléctricas por servicios de erosión de suelos y reciben un segundo pago de los grupos de conservación por la conectividad mantenida. Dicho apilamiento de servicios podría ser útil para aumentar los pagos realizados y como un pago secundario para un cambio más significativo del uso de suelos.

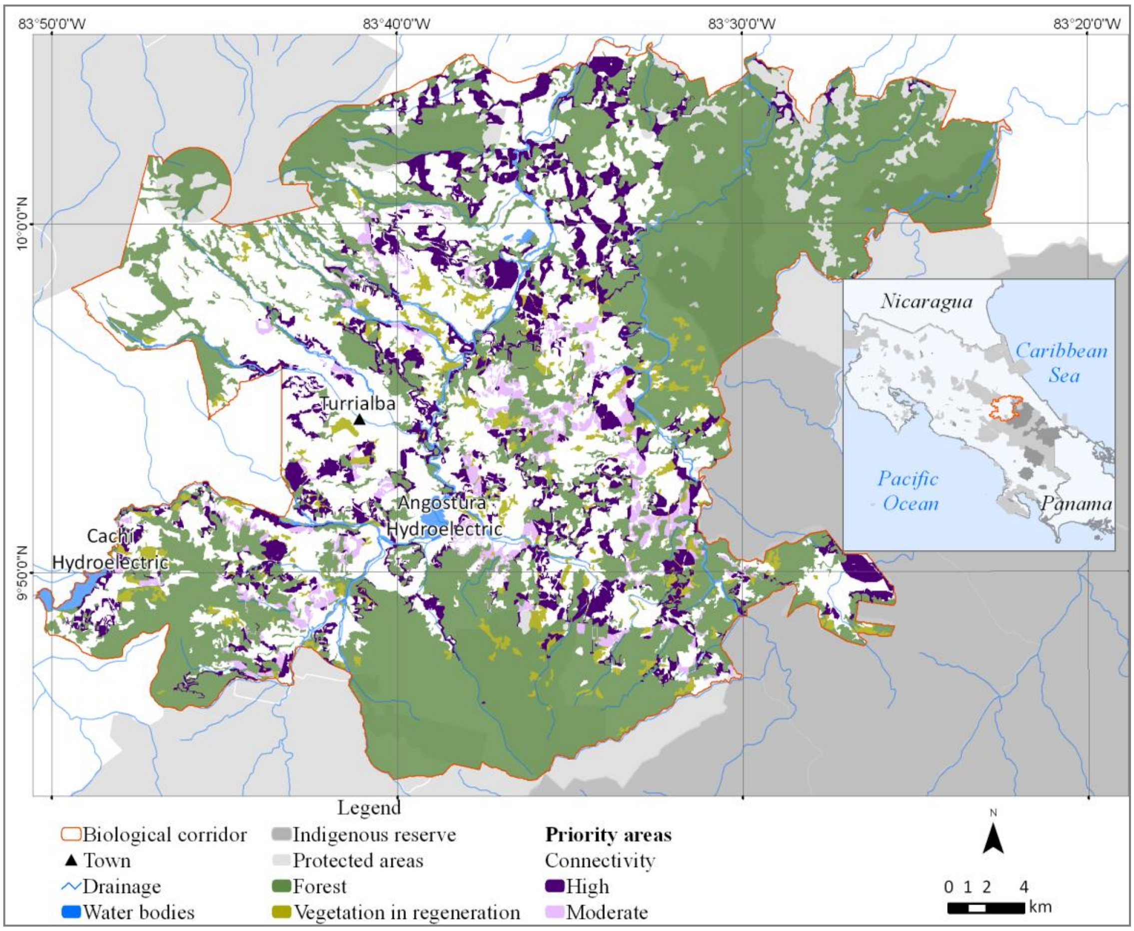


Figura 4: Parcelas cruciales para mantener la conectividad biológica del mosquiterito aceitunado. Al igual que con el modelo de erosión, tales ejercicios de modelación pueden emplearse para identificar cuáles porciones del paisaje deben mantenerse o transformarse en usos eco-amigables del suelo como café de sombra, plantaciones con mezcla de especies o bosques.

Conclusiones

Los resultados de ambos estudios y los de los estudios de plagas en los paisajes cafetaleros conducidos por Avelino y DeClerck demuestran con claridad que el espacio tiene importancia. Es decir, el contexto paisajístico que circunda las plantaciones de café incide en la capacidad productiva de dichas plantaciones y también en la capacidad o en el grado en que las mismas plantaciones proveen servicios. Comprender el impacto del espacio a escalas de finca y de paisaje puede ofrecer perspectivas novedosas especialmente en cuanto a los servicios que pueden ofrecer los agricultores a las comunidades vecinas en contraposición a los servicios recibidos en la finca, cuáles servicios deberían ser pagados por los sistemas de pago ecosistémico frente a los que benefician directamente la capacidad productiva de la finca.

Los resultados del presente trabajo pueden encontrarse con más detalle en varios trabajos publicados incluyendo la tesis de maestría de Estrada (2009), el capítulo de un libro publicado por Estrada y DeClerck (2001). Más información sobre nuestro trabajo de paisajes se encuentra en los capítulos del libro publicado por Avelino et al (2011). Finalmente, las reflexiones sobre el valor de la biodiversidad y la importancia de una escala especial pueden encontrarse en un capítulo publicado por DeClerck y LeCoq (2011).

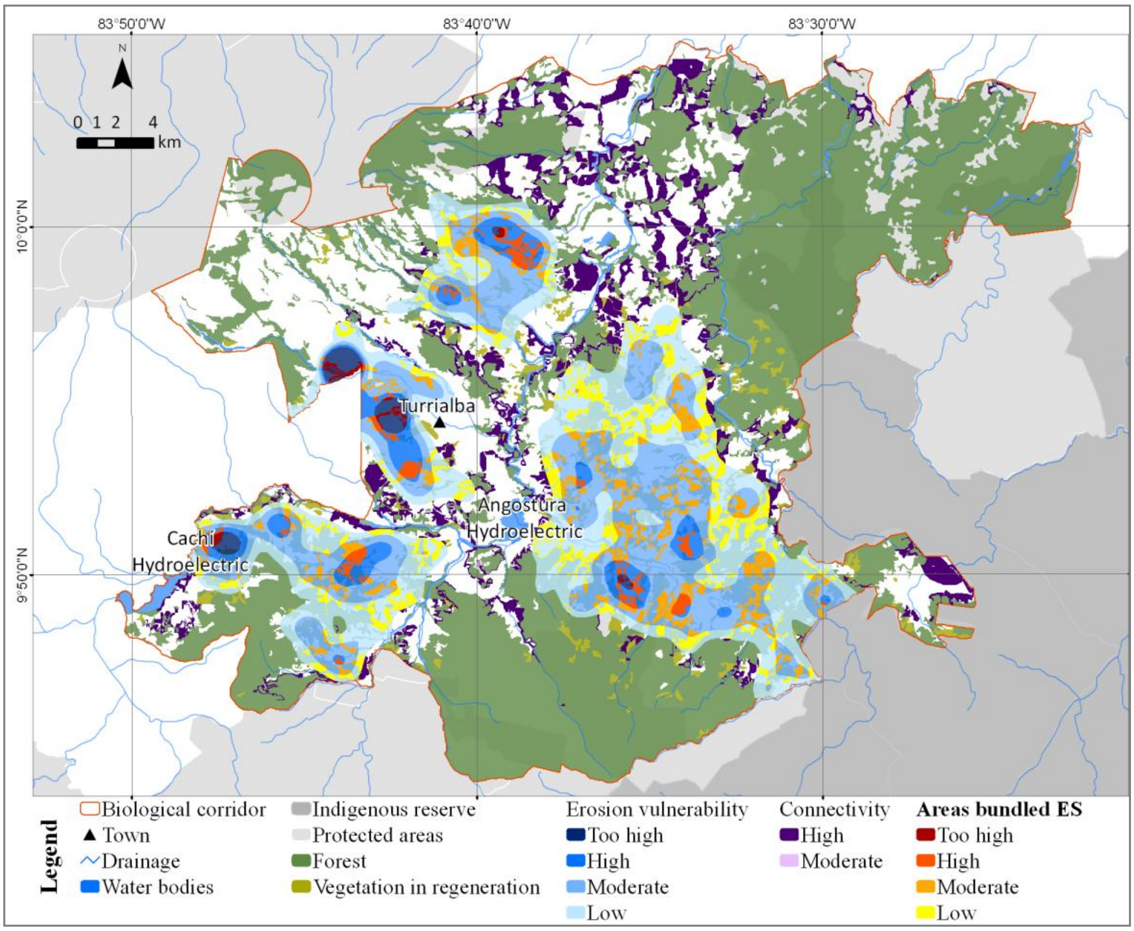


Figura 5: Combinación del mapa de erosión y el mapa de conectividad que muestra la sobreposición especial de ambos servicio. Este modelo puede usarse para establecer áreas prioritarias donde se entrecrucen intereses y los pagos se pueden agrupar o incrementar.

Personal	**Biodiversidad de mamíferos y aves en los paisajes agrícolas**
Investigadores	
Fabrice DeClerck	11 meses-hombre
Natalia Estrada Carmona	12 meses-hombre
Alejandra Martínez-Salinas	4 meses-hombre
Kelly Garbach	2 meses-hombre

Publicaciones para presentar

Capítulos de libros

Avelino J., ten Hoopen M., DeClerck F. 2011. Ecological Mechanisms for Pest and Disease Control in Coffee and Cacao Agroecosystems of the Neotropics En: Ecosystem Services from Agriculture and Agroforestry. Measurement and Payment. Edited By Bruno Rapidel, Fabrice DeClerck, Jean-Francois Le Coq and John Beer. Earthscan. p. 91-118.

DeClerck, F.A.J., Le Coq, J., 2011. The Value of Biodiversity in Agricultural Landscapes In Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. eds B. Rapidel, F.A.J. DeClerck, J. Le Coq, J. Beer, pp. 215-236. Earthscan, Londres.

Estrada Carmona, N. and F.A.J. DeClerck. (2011) Payment for ecosystem services for energy, biodiversity conservation and poverty alleviation. En: Ingram, J.C., F.A.J. DeClerck, and C. Rumbaitis del Rio (eds). Integrating Ecology and Poverty Alleviation and International Development Efforts: a practical guide. Springer. Nueva York.

Tesis de estudiantes

Estrada Carmona, N. 2009. Identificación de áreas prioritarias en la oferta de servicios ecosistémicos para establecer esquemas de Pagos (PSA) direccionados, Costa Rica. Memoria de Maestría, CATIE, Costa Rica, 98 p.

Presentaciones

DeClerck, F.A.J. 2010. The Contribution of Agricultural Landscapes to Connectivity in Biological Corridors. (Keynote). Mesoamerican Congress on Biological Conservation, San José, Costa Rica.

DeClerck, F.A.J. 2011. The Value of Biodiversity. EfD Seminar. CATIE, Turrialba, Costa Rica.

Estrada, N., P. Imbach, and F. DeClerck. 2009. Identifying ecosystem hotspots in coffee-dominated landscapes of Costa Rica for targeted payment for ecosystem service schemes. Second World Congress of Agroforestry. ICRAF, Nairobi, Kenia, 24-27 agosto, 2009.

Estrada Carmona. 2009. Valoración del aporte de los SAF de café en la oferta de algunos SA de acuerdo a su arreglo espacial y tipología de manejo en el Corredor Biológico Volcánica Central Talamanca. Asociación Ornitológica de Costa Rica. San José, Costa Rica.

11.Cuencas y paisaje integración y monitoreo de impactos

Principales resultados:

La "Plataforma Colaborativa CAFNET/Coffee-Flux": medición y modelado de los servicios ecosistémicos de agua, sedimentos y carbono en una cuenca cafetalera agroforestal (Costa Rica).

O. Roupsard[1,2,8], F. Gómez-Delgado[1,4,8], F. Charbonnier[1,2,8], L. Benegas[2,13], K. Welsh[2,11], R. Kinoshita[9], S. Taugourdeau[1], L. Audebert[1], R. Moussa[3], Y. Le Bissonnais[3], B. Rapidel[1,6,8], K. Van den Meersche[1,2,8], J. Avelino[2,8,12], A. Robelo[5], G. Ramirez[5], A. Perez[2], A. Barquero[5], C. Rivera Wilson[2], M. Navarro[1,2], C. Jourdan[1], G. Le Maire[1], J-M. Harmand[1], J. Dauzat[10], J-M. Bonnefond[7], L. Vierling[11,2], J. Eitel[11], P. Vaast[1]

[1] CIRAD, UMR Eco&Sols, F-34060 Montpellier – Francia
[2] CATIE, 7170 Turrialba – Costa Rica
[3] INRA-ENSAM-UMR Lisah – Francia
[4] ICE (Instituto Costarricense de Electricidad) – Costa Rica
[5] Hacienda Aquiares – Costa Rica
[6] CIRAD, UMR System, F-34060 Montpellier – Francia
[7] INRA-UR EPHYSE, Burdeos – Francia
[8] PCP Agroforestry MesoAmerica: Pôle de Compétences en Partenariat
[9] Cornell University – EE.UU.
[10] CIRAD, UMR AMAP, F-34060 Montpellier – Francia
[11] University of Idaho – EE.UU.
[12] CIRAD, UPR Bioagresseurs de pérennes, TA A-31/02, Montpellier F-34398, Francia
[13] Swedish University of Agricultural Sciences (SLU)

Fotografía 1: Cuenca agroforestal de café arábigo en la Hacienda Aquiares (Costa Rica), bajo sombra del árbol *Erythrina poeppigiana*. Foto: Nils Roar.

Objetivos de CAFNET/Coffee-Flux, duración

El objetivo de CAFNET/Coffee-Flux es evaluar los Servicios Ambientales (SA) de agua, sedimento y carbono a escala de cuenca cafetalera agroforestal. Se combina la experimentación, la modelización y la detección remota. El proyecto tendrá una duración de varios años a partir del 2009, con el fin de abarcar las fluctuaciones estacionales e interanuales de la productividad cafetalera y de los servicios ambientales.

La "filosofía" de la plataforma colaborativa

"Coffee-Flux"[1]es una plataforma que inició CAFNET. Promueve la investigación conjunta sobre agroforestería de café: los datos se comparten entre los colaboradores y se promueven las interacciones positivas. La filosofía es concentrar varias investigaciones en un sitio específico y por varios años, incluso después de la finalización de CAFNET, para compartir una útil base de datos experimental, con el propósito de desarrollar modelos y publicar los resultados en publicaciones científicas de alto nivel.

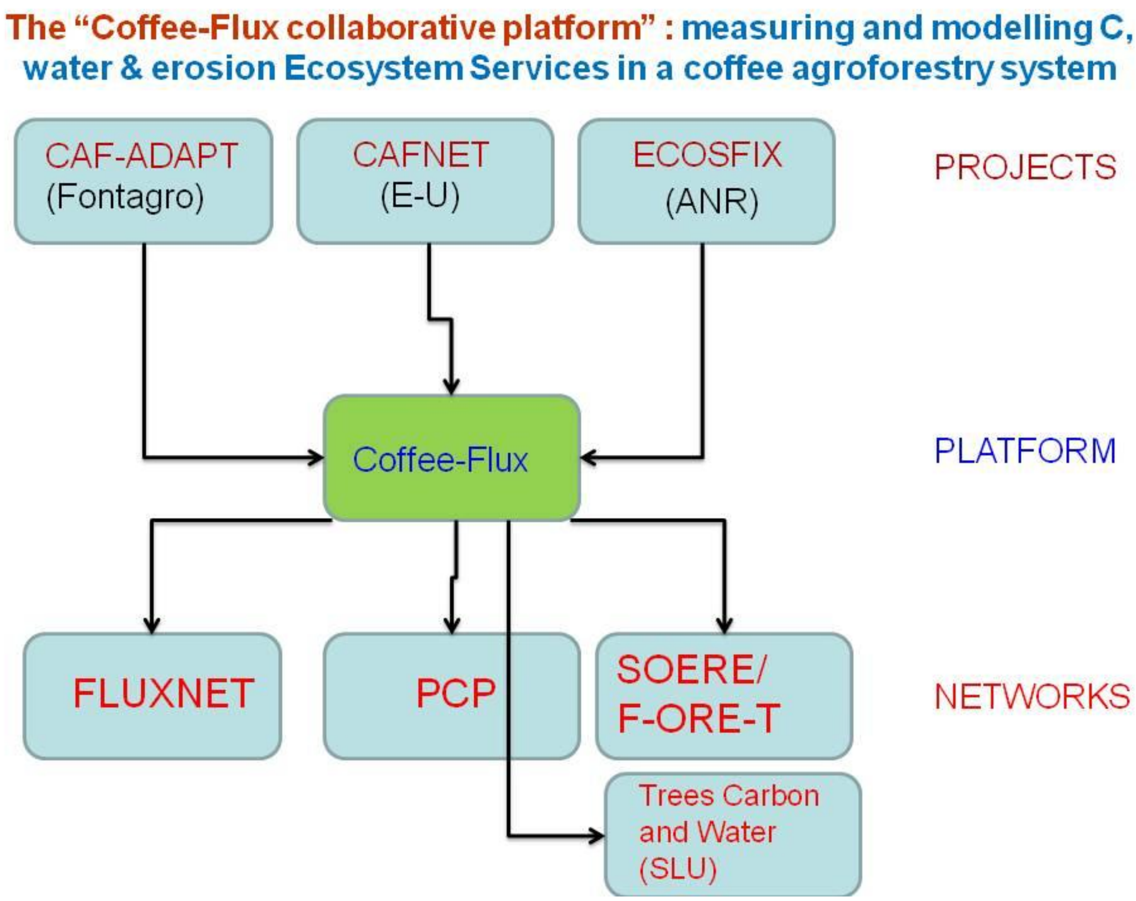


Figura 1.

Coffee-Flux se beneficia de la infraestructura, del fácil acceso al CATIE y de las buenas condiciones de seguridad listas para acoger colaboraciones e investigaciones científicas complementarias. El proyecto se

1

[1]CoffeeFlux:http://www.montpellier.inra.fr/ecosols/recherche/projets_de_recherche_finances/coffeeflux

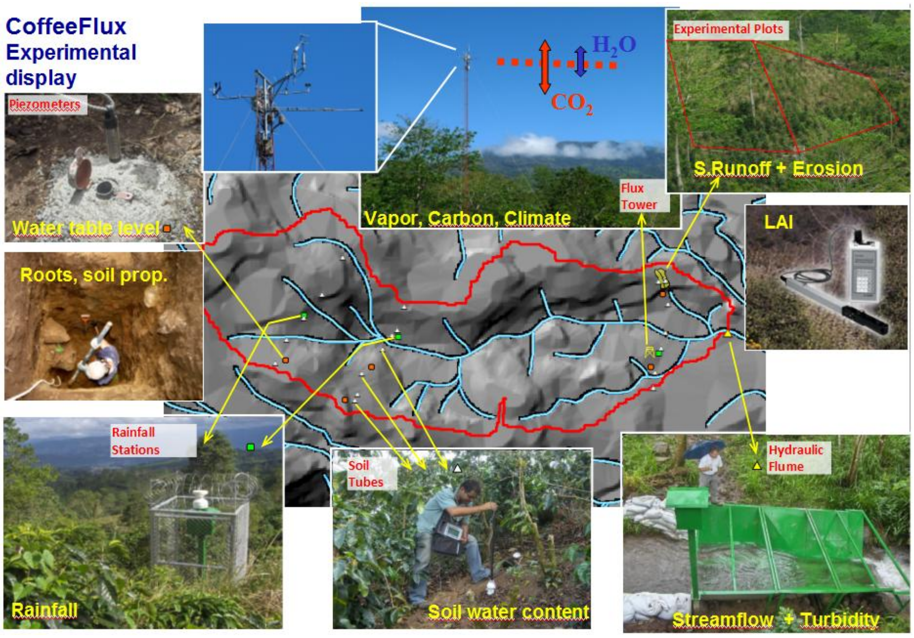
caracteriza por su gran apertura a proyectos complementarios, científicos y, por supuesto, estudiantes, y la base de datos es para compartir.

Socios, patrocinadores y redes

Cirad[2], CATIE[3], PCP[4] y Hacienda Aquiares[5] crearon Coffee-Flux en diciembre de 2009 en Costa Rica. Al principio, fue un subproyecto de CAFNET[6] (EuropAid/121998/C/G) llamado "Conectando y sosteniendo los servicios ambientales y de mercados para café agroforestal en Centroamérica, África del Este e India". Coffee-Flux es un contribuyente de FLUXNET[7] y se convirtió en un **Observatorio** en la red europea y francesa TGIR SOERE F-ORE-T[8] a inicios de 2011.

Descripción del sitio y de la infraestructura

Se eligió una cuenca cafetalera de 1 km^2, con sombra homogénea de altos *Erythrina poeppigiana,* en Aquiares, una de las fincas cafetaleras más grandes del país y con certificación de "Rainforest Alliance". La finca está situada en las faldas del volcán Turrialba, con una elevación entre los 1.020 y 1.280 metros sobre el nivel del mar, y una fuerte influencia de las condiciones climáticas de las montañas caribeñas y sin una fuerte temporada seca. La cuenca está equipada de canaletas automáticas, pluviómetros, detectores de humedad del suelo, piezómetros, turbidímetros, medición del flujo de savia y una torre de covarianza eddy (para flujos de gases H_2O y CO_2).



Fotografía 2.- Presentación experimental de CAFNET/Coffee-Flux

[2] CIRAD: http://www.cirad.fr/
[3] CATIE: http://www.catie.ac.cr/
[4] PCP «Agroforesterie à base de cultures pérennes en Amérique Centrale»: http://www.pcp-agroforestry.org/
[5] Hacienda Aquiares: http://auction.stoneworks.com/includes/crq2004/aquiares_brochure.html
[6] CAFNET: http://www.catie.ac.cr/BancoMedios/Documentos%20PDF/cafnet_carbon_sequestration_mela.pdf
[7] FLUXNET (Global Network of Micrometeorological Tower Sites: http://daac.ornl.gov/FLUXNET/)
[8] Observatoire SOERE/F-ORE-T: http://www.allenvi.fr/?page_id=768

Monitoreo de servicios ambientales

Servicio hidrológico: Coffee-Flux monitorea y desarrolla modelos de la distribución del equilibrio hidrológico (pluviosidad, intercepción, escurrimiento superficial, infiltración, flujo de savia, balance entre agua y suelo, evaporación-transpiración, fluctuaciones acuíferas y flujo total de corriente) y del aporte de sedimentos de la parcela a la cuenca. Además, se han puesto en marcha experimentos de trazado isotópico ^{18}O. Se han obtenido tres (3) doctorados (Gómez-Delgado F., 2010) y hay una (1) maestría en proceso (Kinoshita R.)

Servicio de carbono: Coffee-Flux monitorea el índice de área foliar (IAF) mediante el uso de técnicas de campo y de detección remota (imágenes multiespectrales de alta resolución, MODIS), la productividad primaria neta (PPN: árbol + crecimiento y mortalidad del café) sobre el suelo y debajo de éste (minirhizotrones, rhizotrones), la Productividad Primaria Bruta o (PPB = fotosíntesis del ecosistema), el ecosistema + la respiración del suelo y el Intercambio Neto del Ecosistema (INE) que es el balance de C del ecosistema, usando una covarianza eddy combinada y el crecimiento + monitoreo de la capa vegetal. Un (1) doctorado en proceso (Charbonnier F.) y un dos (2) maestrías obtenidas (Taugourdeau S.; Audebert L.).

Protección contra la erosión: Coffee-Flux monitorea la erosión a nivel de parcela (con árboles y sin ellos) y la sedimentación a nivel de cuenca (mediante el uso del turbidímetro automático). También mencionado en el doctorado de Gómez-Delgado F. (2010).

Resultados específicos (Agosto 2011)

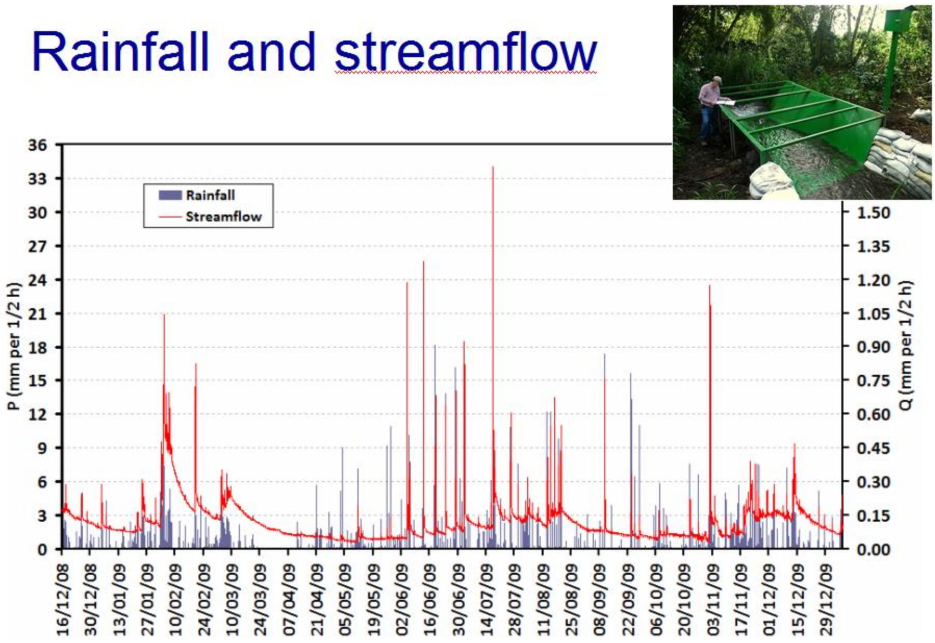


Figura 1. La línea roja representa el transcurso de tiempo del flujo de corriente en la desembocadura de la cuenca Coffee-Flux (canaleta automática) y muestra la gran contribución de la línea base (el acuífero responde en términos de descarga y recarga) + una contribución episódica y bastante baja del escurrimiento superficial (alcanza puntos máximos luego de las precipitaciones). El comportamiento es típico de las cuencas con una gran capacidad de infiltración, bajo escurrimiento superficial y, posiblemente, un bajo transporte de sedimento laminado.

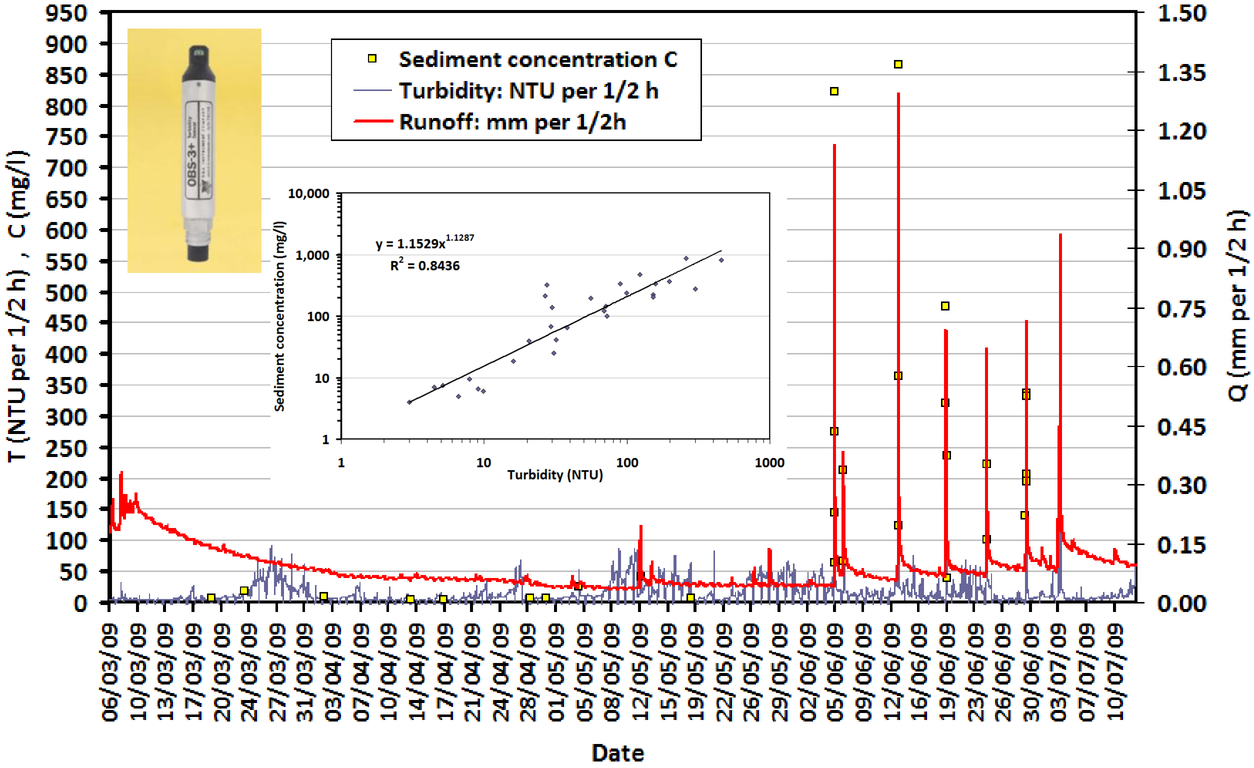


Gráfico 2. Transcurso del tiempo del transporte de sedimento evaluado por el turbiómetro automático (OBS-3, ver fotografía) y la recolección de botellas en la desembocadura de la cuenca. Además, incluye la curva de caudales de turbiedad con respecto a la carga de sedimento.

Figura 2. El transcurso de tiempo del transporte de sedimento evaluado por el turbidímetro (OBS-3) y recolección de botellas en la desembocadura de la cuenca Coffee-Flux. Incluye también la curva de calibración de turbiedad en términos de la carga de sedimentos.

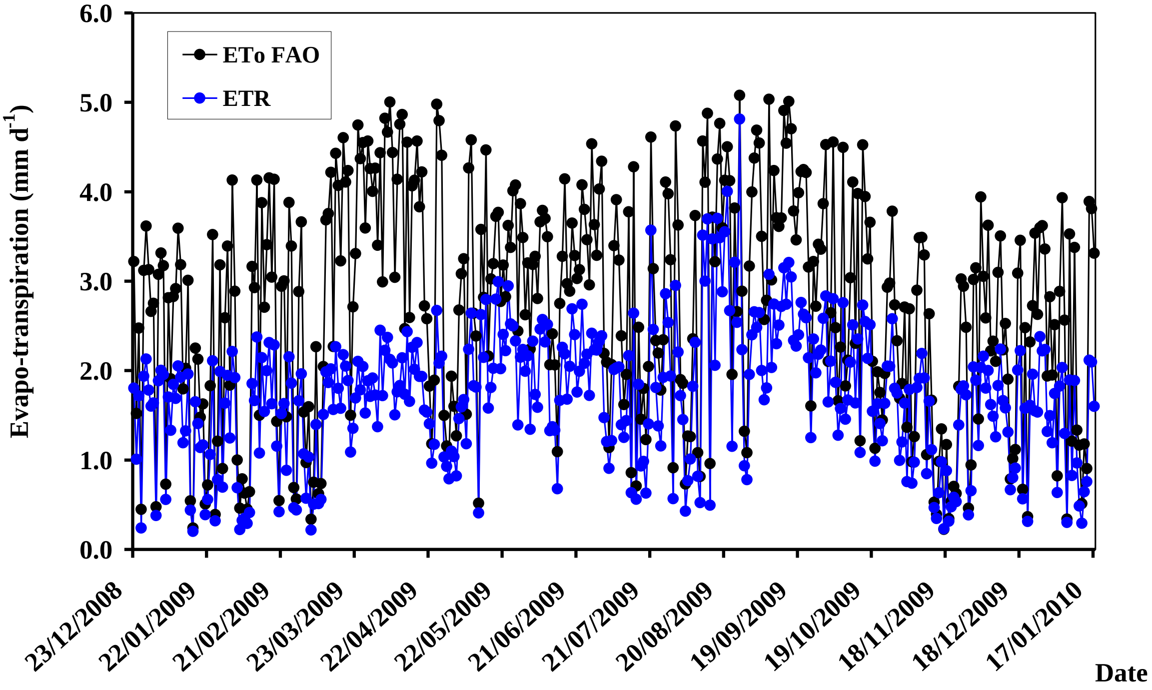


Figura 3. Transcurso de tiempo del potencial diario (ET_0-Penman Monteith, FAO) y evapo-transpiración real (ETR, por covarianza eddy) en la cuenca Coffee-Flux. ETR/ET_0 varía de 0,4 a 0,7 según las fluctuaciones IAF, principalmente.

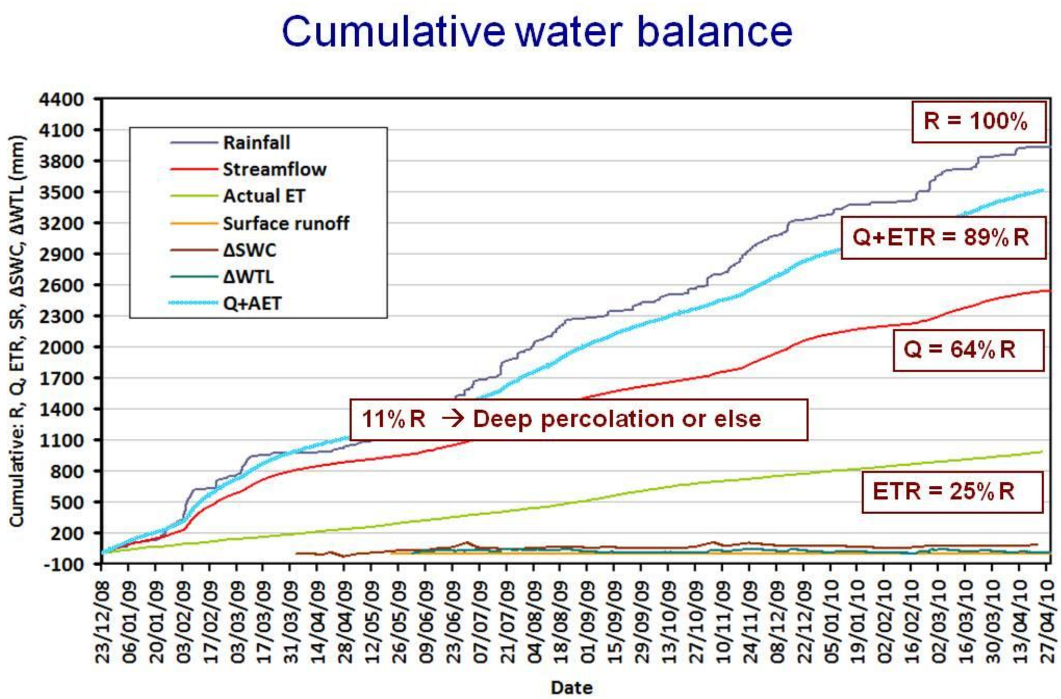


Figura 4. Balance hidrológico acumulativo de la cuenca Coffee-Flux, según mediciones con métodos independientes (ETR por covarianza eddy; Q por canaleta).

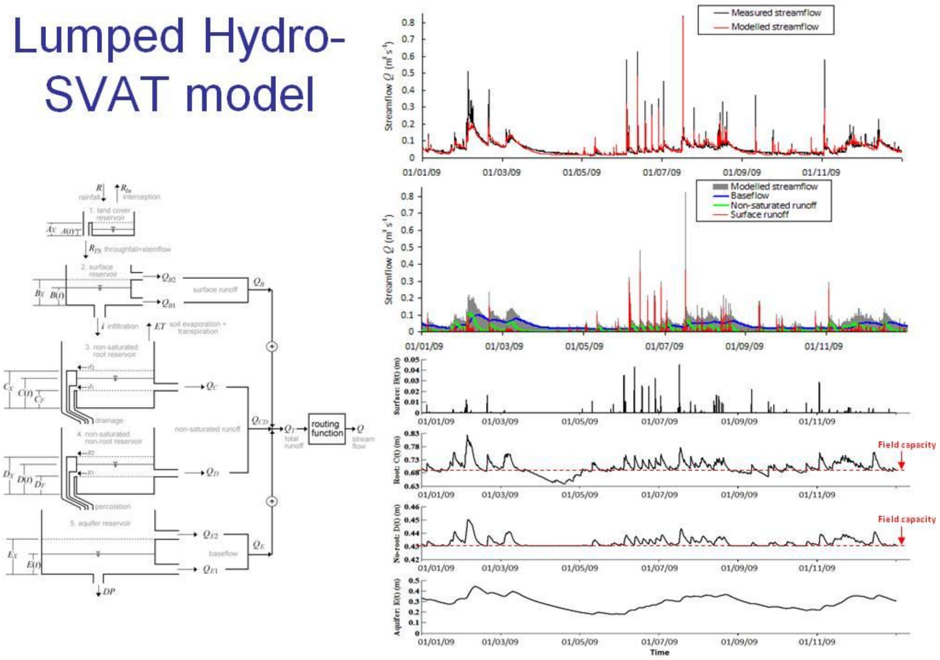


Figura 5. Estructura y simulaciones del modelo Hidro-SVAT agrupado para la división del balance hidrológico de la cuenca Coffee-Flux (Gómez-Delgado et ál, HESS, 2011).

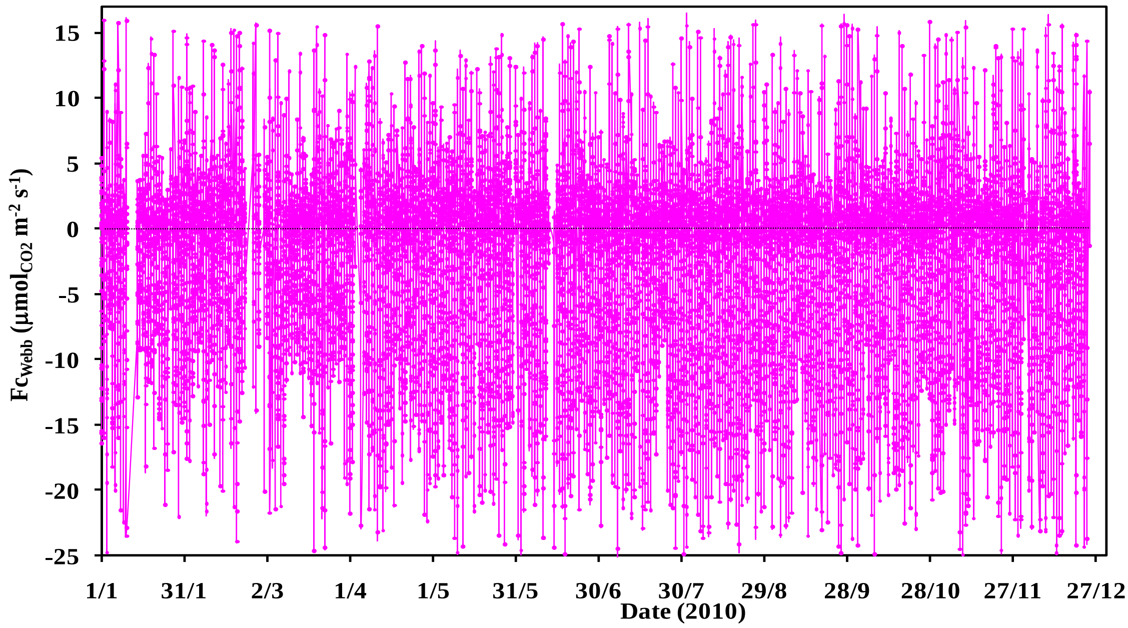


Figura 6. Transcurso de tiempo del intercambio neto de los ecosistemas de carbono (F_c) y su división en respiración del ecosistema (valores positivos, en especial por la noche) y la absorción de C (fotosíntesis + respiración, valores negativos). Un ciclo corresponde a un día; datos del año 2010.

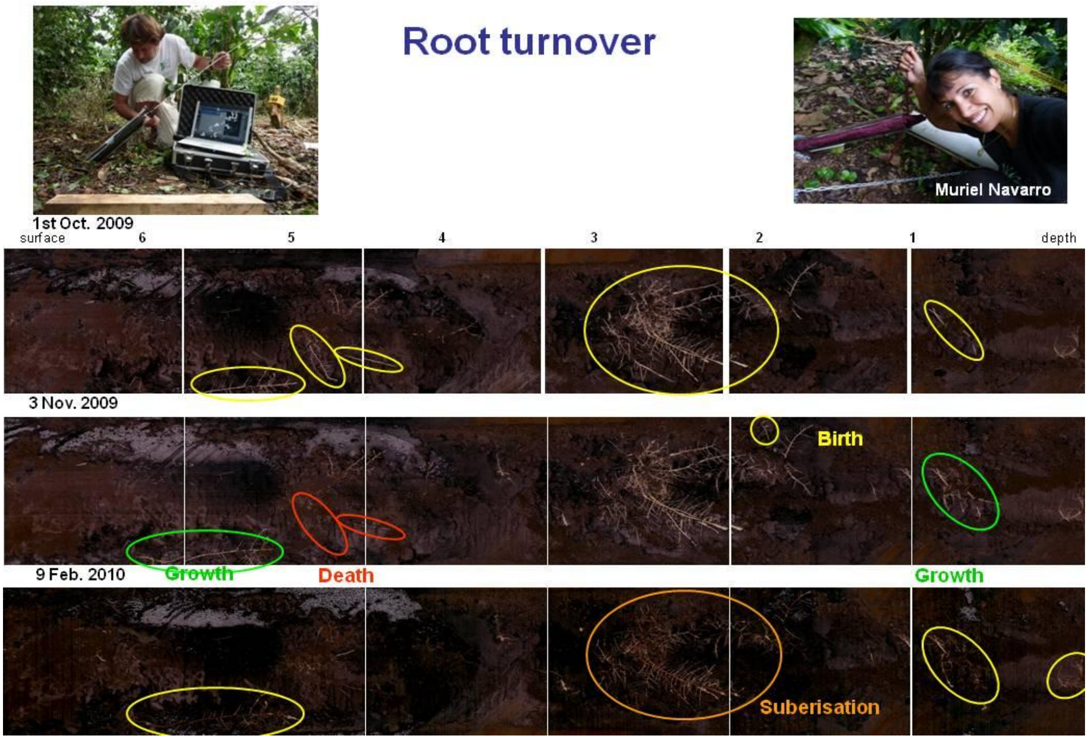


Figura 7. Rotación de raíz (nacimiento, crecimiento, mortalidad) evaluada por minirhizotrones.

Colaboraciones

CATIE: Prof. Francisco Jiménez; Prof. Jeffrey Jones; Prof. Elias De Melo; Prof. Tamara Benjamin; estudiante de doctorado, Laura Benegas; estudiante de doctorado, Pablo Imbach

University of Oslo: Prof. Lars Gottschalk; Dr. Irina Krasovskaia; Prof. Nils Roar

Swedish University of Agricultural Sciences (SLU): Prof. Anders Malmer; Dr. Ulrik Ilstedt

Idaho University (EE.UU.): Dr. Lee Vierling; Dr. Jan Eitel; Prof. Jan Boll

Finca de Aquiares: Don Alfonso Robelo (Presidente); Guillermo Ramírez; Rafael Vargas; Manuel Jara; Alonso Barquero

Publicaciones relacionadas

Audebert L. 2011. Productivité aérienne du café agroforestier : effets de l'ombrage et de l'âge des rejets. Master II. UHP Nancy I, Nancy, France, p 25 pp + Annexes

Soto, M., 2011. ¿Cómo se sabe cuánto carbono captura un cafetal? Periódico La Nación, Costa Rica, 5 de junio de 2011, San José.

Gomez-Delgado, F., Roupsard, O., le Maire, G., Taugourdeau, S., Perez, A., van Oijen, M., Vaast, P., Rapidel, B., Harmand, J.M., Voltz, M., Bonnefond, J.M., Imbach, P., Moussa, R., 2010. Modelling the hydrological behaviour of a coffee agroforestry basin in Costa Rica. Hydrol. Earth Syst. Sci. 15, 369-392.

Gomez-Delgado, F., 2010. Tesis de doctorado. Hydrological, ecophysiological and sediment processes in a coffee agroforestry basin: combining experimental and modelling methods to assess hydrological environmental services. Centre international d'études supérieures en sciences agronomiques - Montpellier Supagro; Ecole doctorale Systèmes Intégrés en Biologie, Agronomie, Géosciences, Hydrosciences, Environnement (SIBAGHE), Montpellier, p. 254.

Roupsard, O., Gomez Delgado, F., Rapidel, B., le Maire, G., 2009. Why is agroforestry so challenging for modellers? How to conciliate complexity, interactions, accuracy and up scaling? A proposed strategy for agroforestry modeling. In: Rapidel, B., Roupsard, O., Navarro, M.N. (Eds.), Modeling Agroforestry Systems. Sesiones de taller. CATIE, Turrialba, Costa Rica, 25-29 February 2008. Serie técnica. Reunión técnica n°14. ISBN 978-9977-57-479-4, pp. 69-80.

Roupsard, O., Gómez-Delgado, F., Moussa, R., Rapidel, B., Perez, A., Barquero, A., Rivera Wilson, C., Benegas, L., Kinoshita, R., Taugourdeau, S., Navarro, M.N.V., Jourdan, C., Le Maire, G., Harmand, J.-M., Bonnefond, J.M., Vaast, P., 2010. The CAFNET/Coffee-Flux project: evaluating water, sediment and carbon ecosystem services in an agroforestry coffee watershed (Costa Rica). 21st Century Watershed Technology: Improving Water Quality and Environment. American Society of Agronomical and Biological Engineers (ASABE), Universidad Earth en Costa Rica. Presentación en póster.

Taugourdeau S. 2010. Indice foliaire d'un système agroforestier à base café, mesure, dynamique et relation avec la production. Master FENEC: Université des Sciences et Technologies du Languedoc, Montpellier, p 12 + anexos.

Taugourdeau, S., Le Maire, G., Roupsard , O., Avelino, J., Gomez Delgado, F., Jones, J.R., Marsden, C., Robelo, A., Alpizar, E., Barquero, A., Rapidel , B., Vaast, P., Harmand, J.M., 2010. LAI dynamics of agroforestry and full sun coffee systems in Costa Rica. Póster. ASIC 2010, Bali, Indonesia, Octubre 3-7 2010. Póster y sesiones.

Talleres

Roupsard, O., Dauzat, J., Le Maire, G., Charbonnier, F., Nouvellon, Y., 2011. Modelling light budgets in Multistrata ecosystems: trade-offs between detailed and scalable models? Presentación oral. Taller PCP: From the Leaf to the Landscape: Field and Remote
Sensing Approaches for Understanding Vegetation Structure and Dynamics, CATIE, Turrialba, Costa Rica.

Visitas

Coffee-Flux es, además, un lugar importante para organizar visitas, ofrecer capacitación y mostrar la colaboración de PCP, CATIE, Aquiares y Cirad. Organizamos una o dos visitas por mes para funcionarios (por ejemplo, el sector cafetalero en Centroamérica), políticos (Brice Lalonde, Embajada de Francia), periodistas (periódico La Nación), profesores universitarios (Noruega, Suecia, Estados Unidos, Inglaterra), grupos de estudiantes (de todos los niveles), y excursiones de campo para congresos (Conferencia Tecnológica sobre Cuencas Siglo XXI de ASABE).

Principales resultados y lecciones para los caficultores

Recomendaciones generales sobre la evaluación y las políticas para servicios ecosistémicos

En cuanto a los Servicios Ecosistémicos (SE), se dan por sentado muchas de las argumentaciones (por ejemplo, los árboles que dan sombra aumentan la infiltración y reducen la erosión; el secuestro de C en el café es nulo porque el café no crece) y se usan sin verificación previa (por ejemplo, al diseñar políticas o esquemas de pago). Coffee-Flux se diseñó para ofrecer una evaluación bastante completa del SE combinado y aumentar a escala desde la parcela hasta la cuenca (incluyendo los recursos no parcelados, tales como las calles o los cauces de los ríos) y, también, con el tiempo (de instantáneo a muchos años). Aquí sólo se evaluó una situación, pero se hizo con un alto nivel de detalle y confianza, utilizando el máximo de métodos independientes que permitieran la validación cruzada y la verificación.

Muy pronto fue evidente que las argumentaciones comunes muestran una gran tendencia a la variabilidad, que su confiabilidad podría depender demasiado de la escala considerada (parcela, cuenca, paisaje, período, etc.) lo cual puede hacer bastante inapropiado el uso sistemático de las mismas. A continuación, presentamos algunos ejemplos de escurrimiento superficial, erosión y secuestro de C.

NB: Los resultados de la plataforma CAFNET/Coffee-Flux son válidos básicamente para las condiciones locales o similares (endosuelos, agroforestería de café con una baja densidad de árboles de sombra (≈15 árboles por ha^{-1}) y no deben extrapolarse de forma descuidada. Según entendemos, sólo se ha hecho un intento hasta ahora para validar los resultados según las diversas condiciones (de suelo, laderas) (Llano Bonito, proyecto Tarrazú, B.Rapidel).

Resultados y recomendaciones principales sobre el agua y la erosión

En Coffee-Flux, el balance del agua de la cuenca se ha cerrado en 89%, lo que es una situación apta para probar más hipótesis (por ejemplo, división del balance del agua; efecto de los contaminantes, etc.); 64%

del aporte de pluviosidad (R: 3000 mm año^{-1}) se convirtió en caudal de agua (Q) y el 25% en evapo-transpiración. El suelo (andosuelo, baja densidad, gran cantidad de raíces, elevada porosidad, alto drenaje) permitía a la mayoría del agua de lluvia drenarse por el suelo profundo y hacia el acuífero, para verterlo después en el caudal. Como resultado, quedaba muy poca agua para escurrimiento superficial. Por esto, la erosión laminar continuaba siendo muy baja (medida a escala de parcela) y el aporte de sedimentos a nivel de la cuenca era de solo 1 t ha^{-1} año^{1}.

Recomendación: Esta situación fue muy favorable para que los agricultores solicitaran el pago por servicios ambientales, alegando el abastecimiento adecuado y continuo del caudal de agua (según lo permitía la gran acumulación/descarga de los acuíferos) y la buena calidad del agua (bajo contenido de sedimentos).

La presencia de árboles de sombra reduce el escurrimiento superficial y el aporte de sedimento en un factor de dos. Sin embargo, la situación general de la cuenca es tan favorable (escurrimiento y erosión bajos) que el beneficio de los árboles se hace insignificante al considerarlo a escala de la cuenca. De hecho, como resultado del bajo rango de sedimento observado a escala de la cuenca, muy poco (≈5%) provenía de las mismas parcelas de café: 65% del sedimento se derivaba del mismo cauce del río (erosión en el río) y del 35% restante, la mayoría procedía de las calles y los senderos ubicados entre las parcelas de café (alto escurrimiento en las calles, alta velocidad de escurrimiento, erosión en el punto de contacto entre las calles y las parcelas).

Recomendación: Para combatir la erosión, sugerimos a los agricultores (i) inspeccionar si la erosión se origina en las parcelas o en los cauces de los ríos; (ii) cuando la mayoría de la erosión NO se deriva de las parcelas, mantener una buena protección alrededor de los cauces (utilizar árboles o corredores de pasto bien arraigado) contra la erosión del río y, en cuanto al contacto entre las calles y las parcelas (cunetas de concreto), así como trincheras a lo largo de las calles para redireccionar el agua de las calles hacia las parcelas donde debe infiltrarse con facilidad; (iii) cuando la erosión es muy baja de manera natural (como sucede en Aquiares), mantener el manejo de corrientes y solicitar el pago por servicios ambientales.

Resultados y recomendaciones principales sobre el almacenamiento de C (secuestro de C s.l)

En nuestro estudio, la productividad primaria neta (PPN= crecimiento visible+capa vegetal+exportaciones) de los retoños del café (después de la poda anual) dio un total de alrededor de 7,6 Mg ha^{-1} año^{-1} (Audebert, 2011). Por supuesto, esto deberá sumarse luego a la productividad de las cepas, de las raíces y de los árboles de sombra, que, según los cálculos podría incrementar la productividad total de la parcela en cerca de 10-15 Mg ha^{-1} año^{-1}. Esto indica un productividad muy baja comparada, por ejemplo, con una plantación de coco con un PPN de 32 Mg ha^{-1} año^{-1} (Navarro et al., 2008) o de eucalipto en Congo (22-32 Mg ha^{-1} año^{-1}, Y. Nouvellon, com.pers.) o bien una plantación de eucalipto en Brasil (irrigado y fertilizado), lo que demuestra un historial de productividad de 50-60 Mg ha^{-1} año^{-1} (Stape et al. 2008). Debemos recalcar que el café es una planta de sombra, con una fotosíntesis relativamente baja. Además, la temperatura promedio del sitio era de sólo 19,8 °C.

El 52% del PPN del retoño del café correspondió a las exportaciones de frutas (Ex), 26% al crecimiento tangible (partes leñosas) (G), y 23% a la mortalidad natural, esto es, la producción de la capa vegetal (L). Del resultado de la suma de L y Ex, concluimos que los vástagos de café invirtieron 75% del C en áreas inestables (frutas, hojas, flores) lo que los clasifica, sin duda, entre los perennes con una inversión prioritaria en áreas de alto rendimiento. Esta propiedad es característica de las frutas tropicales perennes recolectadas por personas y, contrario a lo observado, por ejemplo, en las plantaciones de árboles madereros.

En el caso del café, el almacenamiento de C en las incisiones de resinado perennes (que, por lo general, los métodos IPCC identifican) es relativamente bajo (alrededor de 26% del PPN). Con respecto al almacenamiento de C de las plantaciones con gran productividad y exportación (como el café), es evidente que el destino de C depende menos de la biomasa perenne que en el destino de la capa vegetal (mineralización o incorporación), del manejo de los residuos (destino de la pulpa, del mucílago y del pergamino extraído durante el proceso) y del destino de los retoños podados (madera ortótropa, ya sea para exportación o para conservarla en la parcela para que se descomponga). Consideramos que los métodos del IPCC que se desarrollaron al principio para plantaciones madereras son bastante inadecuados para la evaluación del secuestro de C en plantaciones de frutas perennes en general y, de manera particular, si se pasa por alto el incremento de carbono en estado sólido a partir de la incorporación de la capa vegetal.

Recomendaciones: Deseamos resaltar que la poda anual de cerca de 1/6 de los vástagos (principalmente los más viejos) representa 2.9 t_{DM} ha^{-1} año^{-1}, esto es, 28% de la biomasa por hectárea o también 38% de PPN. Por lo general, los vástagos plagiótropos se dejan descomponer en la parcela, pero la mayoría de los ortotrópicos se exportan. En efecto, estos ortotrópicos representan 60% de la masa de cada sesión de poda, esto es, 1.7 t_{DM} ha^{-1} año^{-1}. Su destino (exportarlo o dejarlo descomponerse) tiende a afectar de modo significativo el destino de la material orgánica del suelo en las parcelas y, por ende, la fertilidad a largo plazo. En consecuencia, en tanto sea factible a nivel económico, debería considerarse la posibilidad de dejar que los vástagos ortotrópicos se descompongan en las parcelas como un Servicio. Resultaría provechoso evaluar, de modo específico, cuál es el impacto de dejar que los vástagos se descompongan en los terrenos o el de no hacerlo.

Tiempo invertido en el componente

Concepto	Costa Rica
Estudiantes : Gomez-Delgado, Benegas, Welsh, Kinoshita, Taugourdeau, Audebert (meses)	69
Equipo CATIE (Jones, Imbach, De Melo, Casanoves) (meses)	2
Equipo CIRAD (Roupsard, Rapidel, Avelino, le Maire, Jourdan) (meses)	19
Total (meses)	90

12.Fortalecimiento de capacidades de las organizaciones para el manejo sostenible de café agroforestal para una mejor participación en los mercados de cafés y diseminación de lecciones y métodos para los actores regionales y nacionales

12.1.Acciones en Nicaragua

Jeremy Haggar-CATIE
Roberto Jerez-CATIE

El entrenamiento de dos cooperativas de café, COOMPROCOM y Guardianes del Bosque, en el desarrollo de negocios rurales (evaluación de cadenas de valores y planes empresariales), iniciado desde 2008 se concluyó en mayo de 2010. Ambas cooperativas presentaron sus resultados en el evento final del proceso y publicaron sus experiencias en el documento final "Cosechando los frutos del cambio organizacional". En base a los planes desarrollados una de las cooperativas, COOMPROCOM ha solicitado con éxito fondos de FUNICA para ejecutar el plan empresarial elaborado.

Para los seguimientos a capacitación se ha coordinado con CRS, SNV, Oxfam, CARE, Rainforest Alliance, NITLAPAN, así como con el programa FONDEAGRO. A nivel de productores se desarrollaron diferentes actividades que están resumidas en el cuadro que sigue:

Tema y Nº talleres (4)	**Organization**	**Men**	**Women**	**Total**
Fertilidad de suelos (1)	COOMPROCOM	20	3	23
Preparación de foliares orgánicos aprobados (2)	COOMPROCOM y Guardianes del Bosque	20	2	2
Manejo integrado de plagas (1)	NITLAPAN	10	1	11

12.2.Acciones en Guatemala:

Alma Quilo-ANACAFE-CATIE
Rudy del Cid-DN

Durante la ejecución del proyecto se realizaron varios eventos de capacitación y fortalecimiento institucional en la zona piloto Sierra la Minas, entre ellas:

a)Apoyo al establecimiento del comité local de instituciones y organizaciones para la promoción de iniciativas sostenibles productivas. Apoyo a la elaboración de un proyecto de fortalecimiento organizacional y productivo para la zona;

b)Talleres sobre análisis de producción y comercialización de café orgánico (Coordinación con Gabriela Soto- CATIE);

c)Capacitaciones en cuatro comunidades (El Carmen, La Trinidad, Las Parcelas, Los Albores) en un trabajo conjunto con CAFNET-PNUD-MARN sobre la temática de cambio climático y servicios ambientales;

d)Taller para técnicos locales en el manejo de SIG para seguimiento a servicios ambientales en zonas cafetaleras (coordinación con Natalia Estrada-CATIE);

e)Taller para técnicos y promotores locales sobre monitoreo de aves en zonas cafetaleras (coordinación con Alejandra Martinez y Elena Florián – CATIE).

f)Talleres en la red de escuelas rurales sobre monitoreo de aves (Coordinación con Cristina Chaluleu) con niños y niñas;

g)Capacitaciones teórico-practicas sobre manejo integral de cafetales (sombra, manejo de tejido, plagas y enfermedades, plan de fertilización) con productores de la zona (Coordinación Elias de Melo-CATIE, Defensores, ANACAFE);

h)Giras de intercambio entre productores experimentadores y productores locales compartiendo avances de las parcelas de validación de buenas prácticas agroforestales en cafetales;

i)Gira a San Jeronimo, coordinación CAFNET-PUND (Byron Medina)-MARN para capacitación sobre esquemas locales de Pago de Servicios Ambientales-PSA por potencial hídrico;

j)Gira con productores y promotores locales a subcuenca del rio El Hato para discusión sobre PSA;

12.3.Acciones en Costa Rica:

Elias de Melo Virginio Filho-CATIE
Gabriela Soto- CATIE
Jean François Le Coq- CIRAD
Beatriz Elizondo-CATIE
Mildred Jimenez-CATIE
Tomaz Gutierrez-ECOM
Carlos Jones Leon- FUNCAFOR
Ana Lucia Corrales- Rainforet Alliance

12.3.1.Acciones coordinadas con comité Corredor Biológico Volcánica Central Talamanca-CBVCT

- Presentaciones compartiendo avances de las investigaciones del proyecto retroalimentando las acciones del comité relacionadas al tema;
- Integración con grupo interinstitucional que forma la red local fortaleciendo capacidades de actores locales (Turrialba, Cashi, Orosi Corralillo);
- Coordinación con el equipo CATIE del proyecto Bosque Modelo Reventazón;

- Vínculos con ICAFE en seguimiento de acciones de capacitación;

12.3.2.Acciones de colaboración con la empresa FJ Orlich-ECOM

La empresa ECOM se ha destacado por un intenso programa de promoción de prácticas sostenibles en fincas cafetaleras. En todo el país la empresa está vinculada con más de 8000 productores de cafés de calidad. Unas 2336 fincas (Georgia, occidente – Orosi) involucradas con el programa Nespresso-AAA. Con CAFNET coordinaron las siguientes acciones:

- Seguimiento a red de parcelas en fincas de aprendizaje sobre buenas prácticas en Sistemas Agroforestales en Café;
- Talleres de capacitación a técnicos y familias productoras:

A) Mitigación, evaluación de vulnerabilidad y adaptabilidad de fincas cafetaleras ante el cambio climático;
B) Avances preliminares de los resultados de los estudios del proyecto CAFNET;

12.3.3.Alianza con la Fundación Café Forestal del consorcio de cooperativas COOCAFE

La Fundación Café Forestal del grupo de Cooperativas de COOCAFE tiene más de 15 años promoviendo capacitación a técnicos y productores, bien como apoyando diferentes iniciativas de cafés sostenibles. El grupo COOCAFE está integrado actualmente por 10 cooperativas de pequeños productores de café (unas 10.000 fincas). Pionera en el país en comercio justo de café. Considerada por estudios de INCAE como uno de los ejemplos más éxitos de integración de cadena y propuestas de cafés sostenibles a partir de la organización de pequeños productores. Entre las acciones desarrolladas con apoyo de CAFNET están:

- Estudio realizados:

A) Potencial de los cafetales de las cooperativas como sumideros de carbono ;
B) Estudio de la percepción de técnicos y productores sobre cambio climático y la caficultura;

- Talleres de capacitación a técnicos y productores de las cooperativas afiliadas y de organizaciones de apoyo sobre mitigación y adaptación a cambio climático;
- Presentación de resultados preliminares de CAFNET;
- Alianza entre CATIE-ICAFE-INTA-FUNCAFOR-COOCAFE para la creación de una nueva categoría de PSA-SAF Café.

12.3.4.Colaboración con la certificadora Rainforest Alliance

- Adecuación de normas y elaboración de Guía de Interpretación – Indicadores para la producción sostenible de café en Costa Rica;
- Elaboración de lista de especies arbóreas presentes en las diferentes zonas y alturas de producción de café en Costa Rica (apoyo entre CATIE y ICAFE);
- Taller de Grupo Técnico Especialista MÓDULO CLIMA DE LA RED DE AGRICULTURA SOSTENIBLE CRITERIOS PARA LA ADAPTACIÓN Y MITIGACIÓN AL CAMBIO CLIMÁTICO. Martes 1 de Junio, 2010. CATIE, Turrialba;

- Plataforma de certificadoras compartiendo y uniendo esfuerzos para mejoramiento de procesos (RA, UTS-Certified, Eco-logica, Nespresso-AAA)

12.3.5.I Feria de devolución a productores (as) cafetaleros (as) de resultados de investigación

En abril de 2009 el proyecto CAFNET en coordinación con la escuela de Posgrado de CATIE y los estudiantes de maestría y doctorado, realizaron una feria-exposición presentando los resultados de investigaciones a más de 100 participantes en su mayoría productores (as) de la zona piloto del proyecto CAFNET en la zona de Turrialba.

Referencias bibliográficas

Florian, E.M. (2008) Zona cafetalera del Corredor Biológico Volcánica Central- Talamanca, Costa Rica. CATIE-CIRAD. 45P.

Jerez, R. (2008) Caracterización zona piloto Peñas Blanca. CATIE-CIRAD, Managua, Nicaragua. 47p.

Anexo 1. Personal Asociado Proyecto CATIE-CAFNET-CIRAD

Actividades	CATIE	CIRAD	Colaboradores(as) en los países
1.Identificación de zonas piloto y seguimiento de comités multi-institucionales en zonas de acción.	Elias de Melo (eliasdem@catie.ac.cr) Jeremy Haggar (jhaggar@catie.ac.cr)	Phillippe Vaast (philippe.vaast@cirad.fr)	Nicaragua: Roberto Jérez-CATIE-CAFNET (jerezni@yahoo.com) Guatemala: Lucrecia Rodríguez-ANACAFE LucreciaR@anacafe.org Oscar Núñez-DEFENSORES onunez@defensores.org.gt Byron Medina bmedina@marn.gob.gt Costa Rica: Mildred Jiménez-CBCVC mildred@catie.ac.cr Aarón Fernández-ICAFE afernandez@icafe.go.cr
2.Conocimiento agroforestal tradicional	Gabriela Soto (gabisoto@catie.ac.cr)	Bruno Rapidel Bruno.rapidel@cirad.fr	Fergus Sinclair/U.GALES (f.l.sinclair@bangor.ac.uk) Nicaragua: Roberto Jérez-CATIE-CAFNET Guatemala: Alma Quilo-ANACAFE Rudi del Cid-Defensores
3.Inventario de biodiversidad	Fabrice DeClerck (fdeclerck@catie.ac.cr) Alejandra Martinez		Costa Rica: Beatriz Elizondo-CATIE-CAFNET (belizondo@catie.ac.cr) Guatemala: Alma Quilo-ANACAFE Rudi del Cid-Defensores Cristina Chaluleu-Consultora
4.Evaluación de impactos ambientales de los SAF café	Jeremy Haggar (jhaggar@catie.ac.cr) Gabriela Soto (gabisoto@catie.ac.cr) Elias de Melo (eliasdem@catie.ac.cr)		Costa Rica: Beatriz Elizondo-CATIE-CAFNET Nicaragua: Roberto Jérez-CATIE-CAFNET Wilber Montenegro-Consultor Guatemala: Alma Quilo-ANACAFE Rudi del Cid-Defensores Cristina Chaluleu-Consultora
5.Validación participativa de prácticas agroforestales sostenibles.	Elias de Melo (eliasdem@catie.ac.cr)	Jacques Avelino (jacques.avelino@cirad.fr)	Costa Rica: Beatriz Elizondo-CATIE-CAFNET Guatemala: Alma Quilo-ANACAFE Rudi del Cid-Defensores Nicaragua: Roberto Jérez-CATIE-CAFNET
6. Valoración económica de servicios ambientales	Gabriela Soto Elias de Melo Jeremy Haggar Guillermo Navarro	Jean .Francois .Le Coq (jean-francois.le_coq@cirad.fr)	Costa Rica: Beatriz Elizondo-CATIE-CAFNET Guatemala: Alma Quilo-ANACAFE Rudi del Cid-Defensores Nicaragua: Roberto Jérez-CATIE-CAFNET
7. Desarrollo de cadenas de valor	Gabriela Soto Guillermo Navarro	Jean .Francois .Le Coq Guy Faure Henry Hocde	Costa Rica: Beatriz Elizondo-CATIE-CAFNET Guatemala: Alma Quilo-ANACAFE Rudi del Cid-Defensores Nicaragua: Roberto Jérez-CATIE-CAFNET
8.Limitantes legales y políticas	Guillermo Navarro (gnavarro@catie.ac.cr)	Jean .Francois .Le Coq (jean-francois.le_coq@cirad.fr)	
9.Desarrollo y mejoramiento de	Fabrice DeClerck	Olivier Roupsard (roupsard@cirad.fr)	

GIS a escala de paisaje			
10.Cuencas y paisajes con SAF	Fabrice DeClerck (fdeclerck@catie.ac.cr)	Olivier Roupsard (roupsard@cirad.fr) Jacques Avelino (jacques.avelino@cirad.fr)	
11.Fortalecimiento de capacidades organizacionales y diseminación	Elias de Melo Jeremy Haggar Gabriela Soto	Jean .Francois .Le Coq	Nicaragua: Roberto Jérez-CATIE-CAFNET Guatemala: Lucrecia Rodríguez-ANACAFE Rosa Maria Aguilar-ANACAFE Alma Quilo-ANACAFE Beatriz Moreno-ANACAFE Byron Medina –PNUD-MRN Oscar Núñez-DEFENSORES Cesar Tot-DEFENSORES Rudi del Cid- DEFENSORES Costa Rica: Mildred Jiménez-CBCVC Aarón Fernández-ICAFE Beatriz Elizondo-CATIE

ANEXO 2- Lista de miembros del comité colaboración Nicaragua

Institución	Tipo de Organización	Representantes	E-mail y telefono
CATIE	Organización No gubernamental internacional	Jeremy Haggar Roberto Jerez	jhaggar@ibw.com.ni 2657114 jerezni@yahoo.com 8816241
Exportadora ATLANTIC /ECOM	Exportadora de café	Iliana Caldera Reynaldo Sosa Justo Torres	icaldera@ecomtrading.com rsoza@ecomtrading.com jpastor@ecomtrading.com teléfonos 7725434, 7725311, 7727151 celular Justo 8209101
FONDEAGRO	Programa Gubernamental	Lars Ericsson Calos Mejía	7726320 cmejia@fondeagro.org.ni Celular: 8541284
CAFENICA	Asociaciones de Cooperativas de Café	Martha Estela Henry Mendoza,	cafenica@turbonett.com.ni, 7724049 celular Henry 6135665
MARENA	Ministerio de Recursos Naturales	Jacobo Sánchez Yadira Meza	jsanchez@reservasdebiosfera.gob.ni ymeza@reservadebiosfera.gob.ni 2331594, 2632370
Rainforet Alliances	Agencia certificadora	Paulina Zeledón	pzeledon@ra.org 8502788, 2708525
NITLAPAN	Programa universitario	Elias Ramirez Guillermo Ponce	nitlactaf@ns.uca.edu.ni 8854026, 2781343 8488886
COOMPROCOM	Cooperativa	Ervin Miranda	coomprocomrl@hotmail.com 8579257

ANEXO 3- Lista de miembros comité- Costa Rica

Institución	Tipo de Organización	Representantes	E-mail y teléfono
CATIE	Organización No gubernamental internacional	Elena Florian Elias de Melo Mildred Jimenez Roger Villalobos	eflorian@catie.ac.cr eliasdem@catie.ac.cr (506) 2558 2602 mildred@catie.ac.cr (506) 2558 2453 rvillalo@catie.ac.cr (506) 2558 2320
ECOM-JFOrlich	exportadora de café	Tomaz Gutierrez	tfgutierrez@ecomtrading.com
APOT	Asociación de productores	Buenaventura Gamboa	venturagamboa@gmail.com (506) 2558 2350
MINAE	Ministerio de Ambiente	Oscar Fonseca Vanessa Zamora Porras	ofonse@costarricense.cr (506) 2559-1220 vanessa2p23@costarricense.cr
CONAF	Comisión Nacional Agroforestal	Wilber Sequeira Vindas	wilseq@costarricense.cr
Rainforest Alliances	Agencia Certificadora	Ana Lucía Corrales	acorrales@ra.org
ICAFE	Instituto Nacional del Café	Aarón Fernández C Juan José Obando	afernandez@icafe.go.cr jobando@icafe.go.cr
UCR	Universidad	Ana Tapia Lolita Durán U	atapia@cariari.ucr.ac.cr lduranu@yahoo.com
SINAC	Agencia gubernamental	Mario Coto Hidalgo	mario.coto@sinac.go.cr
MAG	Ministerio de Agricultura	Carlos Seas Tencio	cgseas@ice.co.cr
UTZ CERTIFIED	Agencia Certificadora	Leonardo Sánchez	lsanchez@aceres.net (506) 8371 4453
BMR	Proyecto interinstitucional	Ligia Quirós Quesada Linda Vaillancourt	lquiros@catie.ac.cr lvaillan@catie.ac.cr

ANEXO 4- Lista de miembros comité Guatemala

Institución	Tipo de Organización	Representantes	E-mail y telefono
CATIE	Organización no gubernamental internacional	Elias de Melo Jorge Jiménez Julio López Paez	eliasdem@catie.ac.cr (506) 2558 2602 jjimenez@catie.ac.cr (502) 2366 3407 jlopez.catie@gmail.com (502) 5205 9258
ANACAFE	Asociación Nacional de Café	Lucrecia Rodriguez Rosa Maria Aguilar Alma Quilo	LucreciaR@anacafe.org (502) 2363 3138
FDN-	Organización No gubernamental	Oscar Nuñez Cezar Tot	onunez@defensores.org.gt (502) 2440-8138 y 2471 7942
ADIPSA	Asociación de productores	Hugo Albizures.	
ALBORES	Asociación de productores	Erwin Alvizures	
Empresa Ramirez	Comercializadora café	Jesus Ramirez	

Anexo 5. Documentos producidos por CAFNET en Central América

Tesis de doctorado

Carlos Cerdán (CATIE-Bangor University, 2007-2011). Local knowledge in coffee agroforestry system : how useful is it to assess trade-offs between coffee production and ecosystem services ?

Cliserio Gonzalez Economic Evaluation of Multiple Products from Certified Coffee Agroforestry Systems. CATIE-Bangor University, to defend in 2012 , PENDIENTE DE PRESENTAR LA TESIS 2012.

Fabien Charbonnier: « Productivité primaire nette (NPP) du café agroforestier au Costa Rica et services environnementaux carbone». Université de Nancy, France. Started in September 2010.

Federico Gomez-Delgado. Services Environnementaux hydrologiques (bilan hydrique, érosion) en milieu café au Costa Rica. Doctoral thesis defended in December 2010 at Université de Montpellier, France.

Kristen Welsh. Balance of water and contaminants in various systems of the Reventazon watershed (Costa Rica). PhD project started in 2011. University of Idaho, USA & CATIE, Costa Rica.

Laura Benegas, 2010-2013. The role of trees for groundwater recharge: PhD research plan, CATIE/SLU. Faculty of forest Sciences. Swedish University of Agricultural Sciences (SLU), Umeå/Uppsala/Alnarp.

Martin Noponen Coffee Agroforestry Systems in Costa Rica and Nicaragua: Carbon Emissions vs. Sequestration. CATIE-Bangor University , to defend in 2011

Tesis de maestría

Audebert, L., (2011). Productivité aérienne du café agroforestier : effets de l'ombrage et de l'âge des rejets. Master II. UHP Nancy I, Nancy, France.

Cerdán Cabrera, C.R. (2007). Conocimiento local sobre servicios ecosistémicos de cafeticultores del Corredor Biológico Volcánica Central Talamanca, Costa Rica; Memoria de Master, CATIE, Costa Rica, 69p.

Estrada Carmona, N. (2009). Identificación de áreas prioritarias en la oferta de servicios ecosistémicos para establecer esquemas de Pagos (PSA) direccionados, Costa Rica. Memoria de Master, CATIE, Costa Rica, 98p.

Franco Stuchi, J. (2010). Calidad de vida, sistemas agroforestales y servicios ambientales en el ámbito de la gestión territorial participativa de la zona de amortiguamiento del Parque Internacional La Amistad, Costa Rica; Memoria de Master, CATIE, Costa Rica, 120p.

Hernández Aguilar, J. (2010). Incidencia de enfermedades foliares del café bajo diversos tipos de sombra y manejo de insumos, en sistemas agroforestales, Turrialba, Costa Rica; Memoria de licenciatura ITCR, Costa Rica, 75p.

Kinoshita Rintaro, (2011). Calibrating the VIS-NIR reflectance of soils of a coffee farm. Master of Cornell University (NY-USA)

Kyoung Noh, J. (2009). Conocimiento local sobre plantas medicinales y su relación con las estrategias de vida de los caficultores del Corredor Biológico Volcánica Central- Talamanca, Costa Rica; Memoria de Master, CATIE, Costa Rica, 99p.

López Bravo D.L. (2010). Efecto de la carga fructífera sobre la roya (Hemileia vastatrix) del café, bajo condiciones microclimáticas de sol y sombra, en Turrialba, Costa Rica; Memoria de Master, CATIE, Costa Rica, 99 p.

Montenegro Salas, P.A. (2010). Monitoreo fitosanitario y productivo de sistemas agroforestales en café (Coffea arabica) (CR95, Caturra y F1), Amarillón (Terminalia amazonia), Cashá (Chloroleucon sp.) y Poró (Erythrina poeppigiana) bajo manejos convencionales y orgánicos en Turrialba, Costa Rica.

Moreno Sanchez C. A. (2008) Aplicabilidad de la legislación y las normas de certificación en sistemas agroforestales de café (SAFC) en Costa Rica y sus efectos en la rentabilidad del productor, tesis de Magister Scientiae en Socioeconomía Ambiental, Turrialba, Costa Rica, 162 p.

Narvaez, I. (2010). Estimación de carbono en sistemas agroforestales de café en Costa Rica. Universidad de Nariño. Nariño, Colombia. Pendiente de entregar Cliserio Gonzalez.

Olivas A.P. (2010). Efecto del uso del suelo adyacente al cafetal sobre la dispersión y dinámica poblacional de la broca Hypothenemus hampei Ferrari y la abundancia de enemigos naturales en el cantón de Turrialba, Costa Rica; Memoria de Master, CATIE, Costa Rica, 140 p.

Quispe Guanca J.L, (2008), Caracterización del impacto ambiental y productivo de las diferentes normas de certificación de café en Costa Rica, tesis CATIE, 149 p.

Rebolledo, M.C., (2008). Building a biophysical conceptual model of agroforestry systems with coffee incorporating scientific, expert and farmers knowledge. MSc. Thesis, AgroParisTech, Paris, 32 pp.

Remal, S., (2009). Conceptual and numerical evaluation of a plot scale, process-based model of coffee agroforestry systems in Central America: CAF2007. Master Thesis, SupAgro, Monptellier, 40 pp.

Rivera Cuéllar S. L. (2008) Una aproximación al análisis de la provisión de capitales como determinante en la adopción de sistemas agroforestales de café certificado en Costa Rica. Tesis de Magister Scientiae en Socioeconomía Ambiental, Turrialba, Costa Rica, p. 174

Romero Gurdián A. (2010). Efecto de los sistemas agroforestales del café y del contexto del paisaje sobre la roya, (Hemileia vastatrix), broca (Hypothenemus hampei, Ferrari) y los nematodos (Meloidogyne spp.), con diferentes certificaciones en la provincia de Cartago Costa Rica; Memoria de Master, CATIE, Costa Rica, 102 p.

Salgado Vásquez, J.L. (2010). Fijación de carbono en biomasa aérea y rentabilidad financiera de sistemas agroforestales con café en Turrialba, Costa Rica y Masatepe, Nicaragua. Memoria de Master, CATIE, Costa Rica, 109p.

Sánchez, E. (2011). Efecto de la sombra y del manejo del café sobre la dinámica poblacional de (Hypothenemus hampei Ferrari) en frutos nuevos y remanentes en Turrialba; Memoria de Master, CATIE, Costa Rica, 117 p.

Simon Taugourdeau, (2010). Indice foliaire d'un système agroforestier à base café, mesure, dynamique et relation avec la production. Master FENEC: Université des Sciences et Technologies du Languedoc, Montpellier, p. 12 + annexes.

Tesis de licenciatura

Chavarría Bolaños, N. (2010). Efecto de diferentes sistemas de manejo sobre la calidad del suelo, en fincas cafetaleras de la zona de Turrialba y Orosi. Memoria Licenciatura, UCR, Costa Rica, 81p.

Cruz Cuellar H.F. (2010). Caracterización e impacto del contexto paisajístico y su posible influencia sobre los niveles de Broca Hypothenemus hampei (Ferrari), en la Provincia de Cartago (Costa Rica); Memoria de Bachiller. Universidad del Tolima, Colombia, Facultad de Ciencias. 67 p.

Guifarro Sanchez, S.B. (2010). Evaluación de enfermedades, desarrollo del café (Coffea arábiga) y sombra en fincas agroforestales certificadas en Turrialba y Orosi, Costa Rica; Memoria Licenciatura UNA, Honduras, 74p.

Kinoshita Rintaro (2009). Experimental display for rainfall interception and steady state infiltrability in a coffee agroforestry system of Costa Rica (E.U. CAFNET/Coffee-Flux project in Aquiares farm). Internship report, April to August 2009. Cirad, CATIE, PCP, Turrialba, p 31

Luis Carlos Cuadra Mayorga, Br. Uberne Patricio Alvarado Narváez, Evaluación de Servicios Ambientales de Café Agroforestal en Fincas en el Macizo de Peñas Blancas, Matagalpa.

Zapata Padilla, C.D. (2010). Caracterización agroecológica y rentabilidad de cafetales orgánicos antiguos bajo un sistema agroforestal con manejo semi-tecnificado en Turrialba, Costa Rica; Memoria Licenciatura, UNA, Honduras, 80p.

Articulos publicados en revistas internacionales

Cerdán, C.R., Rebolledo, M.C., Soto, G., Rapidel, B. and Sinclair, F.L., Local knowledge about ecosystem services and biodiversity conservation related with coffee productivity in Costa Rica. Accepted to Agricultural Systems, under revision.

De Clerck Fabrice., Sociedad Mesoamericana para la Biología y la Conservación

FAURE G., LE COQ J.F., RODRIGUEZ N. (2008) Diversidad de las trayectorias y perspectivas de las organizaciones de pequeños productores en Costa Rica frente a la globalización, Revista Centroamericana de Ciencias Sociales, Vol. 5, No 2, pp 109-135

Gómez-Delgado, F., Roupsard, O., le Maire, G., Taugourdeau, S., Pérez, A., van Oijen, M., Vaast, P., Rapidel, B., Harmand, J.M., Voltz, M., Bonnefond, J.M., Imbach, P. and Moussa, R., (2011). Modelling the hydrological behaviour of a coffee agroforestry basin in Costa Rica. Hydrology and Earth System Sciences, 15: 369-392.

Haggar J., Barrios M., Bolaños M., Merlo M., Moraga P., Munguia M., Ponce A., Romero S., Soto G., Staver C., Virginio E. (2011) Coffee agroecosystem performance under full sun, shade, conventional and organic management regimes in Central America. **Agroforestry Systems 82:** 285-301.

Artículos publicados em memórias de conferencias.

Avelino J., DeClerck F., Olivas A.P., Rivera C., Cruz H., Romero A. (2010). Landscape context and movement of coffee pests. In: Agrobiodiversity in Mesoamerica: from genes to landscape: VI Henri A. Wallace Inter-American Scientific Conference Series, Turrialba, Costa Rica, September 20-24, 2010.

Cerdán, C., Soto, G., Martin, E., Rebolledo, M.C., Rapidel, B. and Sinclair, F., (2009). Comparative analysis of farmers' knowledge about ecosystem services and coffee productivity across Mesoamerica, Second World Congress of Agroforestry. ICRAF, Nairobi, Kenya, August 24-27, 2009.

DeClerck, F.A.J. (2010). The Contribution of Agricultural Landscapes to Connectivity in Biological Corridors. (Keynote). Mesoamerican Congress on Biological Conservation, San Jose, Costa Rica.

DeClerck, F.A.J., M. Gomez, D. Abedon and T. Husband. (2009). Living on the Edge: tree arrangement, forest edges, and mammal conservation in coffee agroforests of Costa Rica. 2nd World Congress on Agroforestry. Nairobi, Kenya.

DeClerck, F.A.J. (2011). The Value of Biodiversity. EfD Seminar. CATIE, Turrialba, Costa Rica.

Estrada, N., P. Imbach, and F. DeClerck. (2009). Identifying ecosystem hotspots in coffee-dominated landscapes of Costa Rica for targeted payment for ecosystem service schemes. Second World Congress of Agroforestry. ICRAF, Nairobi, Kenya, 24-27 August, 2009.

Estrada Carmona. (2009). Valoración del aporte de los SAF de café en la oferta de algunos SA de acuerdo a su arreglo espacial y tipología de manejo en el Corredor Biológico Volcánica Central Talamanca. Asociación Ornitológica de Costa Rica. San Jose, Costa Rica.

Faure G., Maitre d'Hotel E., Le Coq J.F. (2010). Les organisations de producteurs agricoles sont-elles garantes d'un meilleur accès des producteurs aux marchés agricoles ? Enseignements d'une étude menée au Costa Rica. Revue internationale de l'économie sociale, RECMA (316): 85-105

Gómez-Delgado, F., Roupsard, O., Moussa, R., Van Oijen, M., Vaast, P., Rapidel, B., Perez, A., Harmand, J.-M., Voltz, M., Le Maire, G., Imbach, P., Bonnefond, J.M., Taugourdeau, S., (2010). Measuring and modelling water balance, erosion and hydrological services in a coffee agroforestry watershed of Costa Rica. 21st Century Watershed Technology: Improving Water Quality and Environment. American Society of Agronomical and Biological Engineers (ASABE), University La Earth Costa Rica, Oral presentation.

Kessari M., Le Coq J.F., (2010), Stratégie des Organisations de Producteurs face à la certification commerce équitable : Cas des coopératives de la filière café au Costa Rica. Communication au 4ème Journées de recherches en sciences sociales, SFER; Rennes 09 et 10 décembre 2010

Le Coq J.F., Froger G., Legrand T., Pesche D., Saenz F., (2010), "Payment for environmental services program in Costa Rica: a policy process analysis perspective", communication au 19ème annual meeting de la Southwestern Social Science Association, Houston, 31 mars-3 avril, 33 p.

Le Coq J.F., Pesche D., Legrand T. Saenz F. (2010). Changement climatique et innovation dans les instruments de politiques publiques : le cas du programme de paiement pour services environnementaux au Costa Rica. Communication au colloque ISDA du 28 au 30 juin 2010, Montpellier.

Le Coq J.F., Pinard F., Gathoni E., Soto G. (2010). The raise of eco-label coffee: a comparative study of their effects on Costa Rican and Kenyan cooperative coffee sector. In : ASIC. 23rd International Conference on Coffee Science (ASIC 2010), October 03-08, 2010, Bali, Indonesia . s.l. : s.n., 4 p. International Conference on Coffee Science. 23, 2010-10-03/2010-10-08, Bali, Indonésie.

Le Coq J.F., Soto G., Lopez J. 2009. Effect of voluntary private standards on coffee commodity chain in Costa Rica [Abstract]. Communication to the World Congress of Agroforestry., Nairobi, Kenya

Le Coq J.F., Soto G., Gonzalez C. (2009). Voluntary standards in coffee sector and payments for environmental services mechanisms, incentives to ES provision by agroforestry systems: The Costa Rican experience [Abstract]. In : Book of abstracts of the 2nd World Congress of Agroforestry, 23-28 August 2009, Nairobi, Kenya : Agroforestry, the future of global land use. Nairobi : WCA [Nairobi], p. 247-248. World Congress of Agroforestry. 2, 2009-08-23/2009-08-28, Nairobi, Kenya.

Le Coq, J.F., Rapidel, B. and Navarro, M., (2009). Conclusions and perspectives of Modelling Agroforestry Systems in Centroamerica: specificities, new issues and further orientations Modelling Agroforestry Systems. CATIE, Turrialba, Costa Rica, Feb 25-29, 2008.

Le Coq, J.F., Saenz, F., (2009). Policy process and Farmers' organization empowerment: How models can help? In: Rapidel, B. et al (Eds.), Modelling agroforestry systems : Workshop Proceedings,Turrialba, Costa Rica, 25-29 February 2008. - Turrialba : CATIE.

Maitre d'Hotel, E., Le Coq, J.-F., Saenz, F., (2009). Rural producers' organizations' participation in policy-making processes: Explaining dynamics through a comprehensive modelling of strategie behaviours. In: Modelling agroforestry systems : Workshop Proceedings,Turrialba, Costa Rica, 25-29 February 2008. - Turrialba : CATIE, pp. 115-124.

Martinez Salinas, A. and F.A.J. DeClerck. (2010). Contribucion de sistemas agroforestales a la conservacion de la avifauna en el Corredor Biologico Volcanica Central Talamanca, Costa Rica. Associacion de Ornitologos de Costa Rica. San Jose, Costa Rica.

Martinez-Salinas, A.M., and F.A.J. DeClerck. (2009). Annual bird dynamics and use of coffee, and cacao agroforest, silvopastoral systems, sugar cane and forest landuses in Turrialba Costa Rica. 2nd World Congress on Agroforestry. Nairobi, Kenya. *Recipient of Poster Prize for "Greatest Agroforestry Innovation"*

Martinez-Salinas, A. and Fabrice DeClerck. (2009) Coffee Biodiversity in Costa Rica. Rainforest Alliance Workshop of Reviewing Certification Standards. San Jose, Costa Rica. 2009.

Moreno C., Navarro G., Le Coq J.F., Soto G. (2009). Farmers perception and economic constraints in the implementation of the legal framexork and voluntary certification systems influencing coffee agro forestry systems (AFSC) in Costa Rica [Abstract] [Poster]. In : 2nd World Congress of Agroforestry, 23-28 August 2009, Nairobi, Kenya. s.l. : s.n., 1 p. World Congress of Agroforestry. 2, 2009-08-23/2009-08-28, Nairobi, Kenya.

Olivas A.P., Rivera C., Dufour B., Hidalgo E., DeClerck F., Avelino J. (2010). Micro-landscape context effects on the dispersal of coffee berry borer (Hypothenemus hampei) in Costa Rica. In: 23rd International Conference on Coffee Science, 3-8 October 2010, Bali, Indonesia.

Olivas A.P., Rivera C., Dufour B., Hidalgo E., DeClerck F., Avelino J. (2010). Micro-landscape context effects on the dispersal of coffee berry borer (Hypothenemus hampei) in Costa Rica. In: Agrobiodiversity in Mesoamerica: from genes to landscape: VI Henri A. Wallace Inter-American Scientific Conference Series, Turrialba, Costa Rica, September 20-24, 2010.

Pinard F., Le Coq J.F., Aithal A.T. (2010). Coffee sector efficiency and equity: lesson learned from a comparative commodity chain analysis of Costa Rican and Kenyan coffee sector. In : ASIC. 23rd International Conference on Coffee Science (ASIC 2010), October 03-08, 2010, Bali, Indonesia . s.l. : s.n., 3 p.

Rapidel B., Roupsard O. and Navarro M. (2009). Introduction to the workshop. In: Rapidel B., Roupsard O. and Navarro M.N. (eds) Modelling Agroforestry Systems Workshop Proceedings CATIE, Turrialba, Costa Rica, 25-29 February 2008. Tropical Agricultural Research and Higher Education Center (CATIE). Technical Series. Technical meetings n°14. ISBN 978-9977-57-479-4, pp 17-20.

Rapidel B., Rivera C. and Roupsard O. (2009). Sapflow in coffee: comparison of two methods -heat balance and heat dissipation-calibration and applicability in the field 2nd World Congress of Agroforestry (2009), Nairobi, Kenya. Poster.

Rapidel, B. and Van Oijen, M., (2009). Coffee productivity, ecosystem services provision and adaptation to climate change: how useful can be a model?, Second World Congress of Agroforestry. ICRAF, Nairobi, Kenya.

Rapidel, B., (2008). Bienes y servicios ambientales de la caficultura, 19 Congreso Nacional del Café. ANACAFE, Guatemala.

Rapidel, B., Beer, J. and Vaast, P., (2009). The Mesoamerican Scientific Partnership Platform (PCP) Agroforestry Systems with Perennial Crops, Modelling Agroforestry Systems. CATIE, Turrialba, Costa Rica, Feb 25-29, 2008.

Rapidel, B., Roupsard, O. and Navarro, M. (Editors), (2009). Modelling Agroforestry Systems. Workshop Proceedings, CATIE, 25-29 february, 2008. CATIE, Turrialba, 336 pp.

Rebolledo, M.C., Rapidel, B., Avelino, J. and Sinclair, F., (2009). Building a biophysical conceptual model of Agroforestry Systems (AFS) with coffee incorporating scientific, expert and farmer's knowledge in Costa Rica. In: B. Rapidel, O. Roupsard and M. Navarro (2008) (Editors), Modelling agroforestry systems CATIE, Turrialba, Costa Rica, 25-28 Feb 2008.

Rodrigues, G.C., Rojas, J.S.D., Roupsard , O., Leroy, T., Pot, D., Moreira, M.Z., Verdeil, J.-L., Dauzat, J., Jourdan, C., Andrade, A.C., Marraccini, P., (2010). Preliminary results on phenotypic plasticity of coffee (C. arabica cv. Rubi and Iapar59) plants in response to water constraint under field conditions. ASIC 2010, Bali, Indonesia, October 3-7 2010.

Romero A., Cruz H., De Melo E., DeClerck F., Avelino J. (2010). Landscape context and plot incidence of coffee rust (Hemileia vastatrix), coffee berry borer (Hypothenemus hampei) and the Root-knot nematodes Meloidogyne spp. in Costa Rica. In: 23rd International Conference on Coffee Science, 3-8 October 2010, Bali, Indonesia.

Romero A., Cruz H., De Melo E., DeClerck F., Avelino J. (2010). Relationships between landscape context and coffee rust (Hemileia vastatrix), coffee berry borer (Hypothenemus hampei) and the rootknot nematodes Meloidogyne spp. in Costa Rica. In: Agrobiodiversity in Mesoamerica: from genes to landscape: VI Henri A. Wallace Inter-American Scientific Conference Series, Turrialba, Costa Rica, September 20-24, 2010.

Rodrigues, G.C., Rojas, J.S.D., Roupsard , O., Leroy, T., Pot, D., Moreira, M., Verdeil, J.L., Dauzat, J., Jourdan, C., Andrade, A. and Marraccini, P., (2010). Preliminary results on phenotypic plasticity of Coffee (Coffea arabica CV. Rubi and IAPAR59) plants in response to water constraint under field conditions., ASIC (Association for Science and Information on Coffee) 2010: 23rd International Conference on Coffee Science, Bali, Indonesia, October 3-7 2010. Poster Communication and Proceedings.

Roupsard, O., Dauzat, J., Le Maire, G., Charbonnier, F., Nouvellon, Y., (2011). Modelling light budgets in Multistrata ecosystems: trade-offs between detailed and scalable models? Oral Presentation. PCP Workshop : >From the Leaf to the Landscape: Field and Remote Sensing Approaches for Understanding Vegetation Structure and Dynamics, CATIE, Turrialba, Costa Rica.

Roupsard, O., Gómez-Delgado, F., Charbonnier, F., Benegas, L., Taugourdeau, S., Kinoshita, R., Moussa, R., Dreyer, E., Lacointe, A., Rapidel, B., Perez, A., Robelo, A., Barquero, A., Rivera Wilson, C., Navarro, M.N.V., Jourdan, C., Le Maire, G., Thaler, P., Bonnefond, J.-M., Harmand, J.-M., Vaast, P., (2010). The CAFNET/Coffee-Flux project: evaluating water, sediment and carbon ecosystem services in an agroforestry coffee watershed of Costa Rica. ASIC (Association for Science and Information on Coffee) 2010: 23rd International Conference on Coffee Science, Bali, Indonesia, October 3-7 2010. Oral Communication, Poster and Proceedings.

Roupsard, O., Gómez-Delgado, F., Moussa, R., Rapidel, B., Perez, A., Barquero, A., Rivera Wilson, C., Benegas, L., Kinoshita, R., Taugourdeau, S., Navarro, M.N.V., Jourdan, C., Le Maire, G., Harmand, J.-M., Bonnefond, J.M., Vaast, P., (2010). The CAFNET/Coffee-Flux project: evaluating water, sediment and carbon ecosystem services in an agroforestry coffee watershed (Costa Rica). 21st Century Watershed Technology: Improving Water Quality and Environment. American Society of Agronomical and Biological Engineers (ASABE), University La Earth Costa Rica, Poster presentation.

Roupsard O., Gomez Delgado F., Kinoshita R., Benegas L., Perez A., Barquero A., Rivera Wilson C., Rapidel B., Vaast P. and Moussa R. (2009). El Proyecto CAFNET/Coffee-Flux : midiendo y modelando Servicios Ambientales (H2O, CO2 y erosión) en un SAF de café. Semana cientifica del CATIE 2009 Oral comm, CATIE, Turrialba, Costa Rica.

Roupsard O., Gomez Delgado F., Rapidel B. and le Maire G. (2009). Why is agroforestry so challenging for modellers? How to conciliate complexity, interactions, accuracy and upscaling? A proposed strategy for agroforestry modelling. In: Rapidel B., Roupsard O. and Navarro M.N. (eds) Modelling Agroforestry Systems Workshop Proceedings CATIE, Turrialba, Costa Rica, 25-29 February 2008 Technical Series Technical meetings n°14 ISBN 978-9977-57-479-4, pp 69-80.

Roupsard O., Gómez-Delgado F., Rapidel B., Kinoshita R., Perez A., Moussa R., Jourdan C., Le Maire G., Harmand J.-M., Bonnefond J.M. and Vaast P. (2009). The CAFNET/Coffee-Flux project: evaluating water, sediment and carbon ecosystem services in an agroforestry coffee watershed (Costa Rica). 2nd World Congress of Agroforestry (2009), Nairobi, Kenya. Poster.

Roupsard O., Gómez-Delgado F., Rapidel B., Kinoshita R., Perez A., Moussa R., Jourdan C., Le Maire G., Harmand J.-M., Bonnefond J.M. and Vaast P. (2009). Scaling the water, C and sediment partitioning from plot to watershed: COFFEE-FLUX, a coffee agroforestry experiment in Costa Rica. Asiaflux Workshop, October 27-29, Sapporo, Japan. Poster presentation.

Sáenz-Segura F, Le Coq JF, Arce-Alvarado R, Alonso-Ubieta S (2007) - Innovative collective actions to provide public/private services to farmers' organizations in the coffee sector: A theoritical background – communication to the Second International Symposium on Multi-Strata Agroforestry Systems with Perennial Crops: Making ecosystem services count for farmers, consumers and the environment, 17 – 21 Septembre 2007, Turialba, Costa Rica

Soto, G., Quispe, J. (2009). Farmers perception and economic constrains in the implementation of the legal framework and voluntary certification systems influencing coffee AFS in Costa Rica. [Abstract]. In : Book of abstracts of the 2nd World Congress of Agroforestry, 23-28 August 2009, Nairobi, Kenya : Agroforestry, the future of global land use. Nairobi : WCA [Nairobi], p. 247-248. World Congress of Agroforestry. 2, 2009-08-23/2009-08-28, Nairobi, Kenya.

Taugourdeau, S., Le Maire, G., Roupsard , O., Avelino, J., Gomez Delgado, F., Jones, J.R., Marsden, C., Robelo, A., Alpizar, E., Barquero, A., Rapidel , B., Vaast, P. and Harmand, J.M., (2010a.) LAI dynamics of agroforestry and full sun coffee systems in Costa Rica. Poster, ASIC 2010, Bali, Indonesia, October 3-7 2010. Poster Communication and Proceedings.

Taugourdeau, S., Le Maire, G., Roupsard , O., Avelino, J., Gomez Delgado, F., Jones, J.R., Marsden, C., Robelo, A., Alpizar, E., Barquero, A., Rapidel , B., Vaast, P. and Harmand, J.M., (2010b.) LAI dynamics of agroforestry and full sun coffee systems in Costa Rica. Poster, XIth ESA Congress AGRO 2010, Montpellier, France.

Vaast P., Harmand J.-M. and Roupsard O. (2009). The EU-Casca Project:databases and models. In: Rapidel B., Roupsard O. and Navarro M.N. (eds) Modelling Agroforestry Systems Workshop Proceedings CATIE, Turrialba, Costa Rica, 25-29 February 2008 Technical Series Technical meetings n°14 ISBN 978-9977-57-479-4 pp 253-262

Van Oijen, M., Dauzat, J., Harmand, J.-M., Lawson , G. and Vaast, P., (2009.) Plot-scale modelling of coffee agroforestry systems in Central America. In: B. Rapidel, O. Roupsard and M. Navarro (Editors), Modelling agroforestry systems. CATIE, Turrialba, Costa Rica, 25-28 Feb 2008.

Capítulos de libros

Avelino J., ten Hoopen M., DeClerk F. (2011). Ecological Mechanisms for Pest and Disease Control in Coffee and Cacao Agroecosystems of the Neotropics. In: Ecosystem Services from Agriculture and Agroforestry. Measurement and Payment. Edited By Bruno Rapidel, Fabrice DeClerck, Jean-Francois Le Coq and John Beer. Earthscan. p. 91-118. No publicar en el CD, ni distribuir sin autorizacion de los autores.

DeClerck, F.A.J., Martinez-Salinas, A., (2011). Measuring Biodiversity, In Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. eds B. Rapidel, F.A.J. DeClerck, J. Le Coq, J. Beer, pp. 65-90. Earthscan, London. No publicar en el CD, ni distribuir sin autorizacion de los autores.

DeClerck, F.A.J., Le Coq, J., (2011). The Value of Biodiversity in Agricultural Landscapes, In Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. eds B. Rapidel, F.A.J.

DeClerck, J. Le Coq, J. Beer, pp. 215-236. Earthscan, London. No publicar en el CD, ni distribuir sin autorizacion de los autores.

Natalia Estrada Carmona and Fabrice DeClerck, Payment for Ecosystem Services for Energy,Biodiversity Conservation, and Poverty Alleviation.

Hergoualc'h, K., (2011). Principles and Methods for Assessing Climate Change Mitigation as an Ecosystem Service in Agroecosystems In: B. Rapidel, F. DeClerck, J.F. Le Coq and J. Beer (Editors), Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. Earthscan, London, UK, pp. 19-36. No publicar en el CD, ni distribuir sin autorizacion de los autores.

Idol T. , Haggar J., & Cox L. (2011) Ecosystem Services from Smallholder Forestry and Agroforestry. In eds Campbell B. & Lopez S. **Issues in Agroecology: Present Status and Future Prospects**. Springer

Le Coq J.F., Soto G., González Hernández C. (2011). PES and Eco-Label. A comparative analysis of their limits and opportunities to foster environmental services provision. In : Rapidel Bruno (ed.), Le Coq Jean-François (ed.), Beer John (ed.). Ecosystem services from agriculture and agroforestry : Measurement and payment. Londres : Earthscan Publications, p. 237-264. No publicar en el CD, ni distribuir sin autorizacion de los autores.

Marchamalo, M., Vignola, R., Gómez-Delgado, F. and González-Rodrigo, B., (2011). Quantifying Services and Identifying Watershed Priority Areas for Soil and Water Conservation Programmes. In: B. Rapidel, F. DeClerck, J.F. Le Coq and J. Beer (Editors), Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. Earthscan, London, UK, pp. 37-64. No publicar en el CD, ni distribuir sin autorizacion de los autores.

Rapidel, B., DeClerck, F.A.J., Le Coq, J., J., B., (2011). Introduction, In Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. eds B. Rapidel, F.A.J. DeClerck, J. Le Coq, J. Beer, pp. 1-15. Earthscan, London. No publicar en el CD, ni distribuir sin autorizacion de los autores.

Rapidel, B., Le Coq, J., DeClerck, F.A.J., Beer, J., (2011). Measurement and Payment of Ecosystem Services from Agriculture and Agroforestry: New Insights from the Neotropics, In Ecosystem Services from Agriculture and Agroforestry: Measurement and Payment. eds B. Rapidel, F.A.J. DeClerck, J. Le Coq, J. Beer, pp. 377-396. Earthscan, London. No publicar en el CD, ni distribuir sin autorizacion de los autores.

Soto G., Le Coq J.F. (2011). Certification process in the coffee value chain. Achievements and limits to foster provision of environmental services. In : Rapidel Bruno (ed.), Le Coq Jean-François (ed.), Beer John (ed.). Ecosystem services from agriculture and agroforestry: Measurement and payment. Londres : Earthscan Publications, p. 319-345. No publicar en el CD, ni distribuir sin autorizacion de los autores.

Artículos submetidos

Avelino, J., A. Romero-Gurdián, H. Cruz-Cuellar, and F.A.J. DeClerck. (In Review). Landscape context and scale differentially impact coffee leaf rust, coffee berry borer and coffee root-knot nematodes. Submitted to Ecological Applications on 05/13/2011.

Cerdán, C.R., Soto, G., Lamond, G., Sinclair, F.L. and Rapidel, B., Farmer's knowledge of ecosystem services and coffee productivity in Northern Nicaragua. Submitted to Agroforestry Systems. En tramite para su publicacion.

DeClerck, F.A.J. M.J. Gomez, N. Estrada Carmona, V. Loaiza, S. Olsen, C. Yzoard, D. Abedon and T. Husband. (in Prep). Living on the edge: coffee agroforests serve as buffers for small and medium mammals. Biological Conservation.

Fabrice deClerck, Mohammed Ellatifi, Bryan Finegan and Ian Thompson, 6 Forest Biodiversity and Ecosystem Services: Drivers of Change, Responses and Challenges

Faure G., Le Coq JF, Vagneron I., Hocde H., Soto G, (soumis 2010). Stratégie des organisations de producteurs de café au Costa Rica face aux certifications environnementales et sociales. En trámite para su publicacion.

Gomez-Delgado, F., Roupsard, O., Moussa, R., (2011). Water and sediment yield in a coffee agroforestry system at various spatio-temporal scales: from plot to basin and from event to annual scale. In Prep. Agric. Ecos. Envir. En trámite para su publicacion.

González, C; J. Haggar; G. Edwards-Jones; J.F. Le Coq; G. Soto. (por publicar). Almacenamiento de carbono en fincas cafetaleras certificadas en Costa Rica y Nicaragua. Agroforestry Systems. En trámite de publicacion.

Martinez-Salinas, A., and F.A.J. DeClerck. (in Press) The role of agroecosystems in the conservation of birds within biological corridors. Revista de recursos naturales. Turriabla, Costa Rica.

Noponen MRA, Edwards-Jones G, Haggar J, Soto G, Attarzadeh N, Healey JR (submitted) Greenhouse gas emissions and production efficiency in coffee grown with differing input levels under conventional and organic management. Agriculture, Ecosystems & Environment. En tramite para su publicacion.

Quispe Jose, Gabriela Soto, Elias de Melo, Guillermo Navarro, Jeremy Haggar, Characterization of the environmental and productive impact of the different coffee certification standards in Costa Rica. 1Student, Tropical Agriculture Research and Higher Education Center (CATIE), Turrialba Costa Rica; 2CATIE, Costa Rica; 3CATIE, Nicaragua.

Soto Gabriela, Leonardo García, Rodolfo Munguía, Jeremy Haggar, Elias de Melo, Mirna Barrios, Charles Staver y Serita Frey, Impact of conventional and organic coffee agroforestry systems on soil characteristics in an Andisol in Masatepe, Nicaragua and an Ultisol in Turrialba, Costa Rica.

Taugourdeau, S., Le Maire, G., Roupsard , O., Avelino, J., Gomez Delgado, F., Jones, J.R., Marsden, C., Vaast, P., Harmand, J.M., 2011. Leaf area index at the crossroad of environmental services in a coffee agroforestry system. In Prep. Agric. Ecos. Envir. En trámite para su publicacion.

Otros documentos

Attarzadeh, N and Noponen, M. (2010). Carbon footprint of a coffee processing plant: CoopeTarrazú, Los Santos, Costa Rica. Reporte de Consultoría, Costa Rica. 5 p.

Attarzadeh, N and Noponen, M. (2010). Carbon footprint of a coffee conventional farm of 7 has in Los Santos, Costa Rica. Reporte de Consultoría Costa Rica 5 p.

Attarzadeh, N and Noponen, M. (2010). Carbon footprint of Coffee conventional farms (from 25 to 100 hectares). Reporte de Consultoría. Nicaragua. 5 p.

Attarzadeh, N and Noponen, M. (2010). Carbon footprint of coffee conventional farms with less than 5 hectares north of Nicaragua. Reporte de Consultoría Nicaragua, 5p.

Attarzadeh, N and Noponen, M. (2010). Carbon footprint of Coffee Rainforest Alliance certified farms of 25 to 100 hectares in the North of Nicaragua. Reporte de Consultoría. Nicaragua, 5 p.

Attarzadeh, N and Noponen, M. (2010). Carbon footprint of organic certified farms of coffee (10 to 20 has) of Los Santos, Costa Rica. Reporte de Consultoría Costa Rica. 5 p.

Attarzadeh, N and Noponen, M. (2010). Carbon footprint of organic certified coffee farms with less than 2 has in Los Santos, Costa Rica. Reporte de Consultoría, Costa Rica 5 p.

Attarzadeh, N and Noponen, M. (2010). Carbon footprint of Rainforest Alliance certified farms in Los Santos, Costa Rica. Reporte de Consultoría, Costa Rica 5 p.

Attarzadeh, N and Noponen, M. (2010). Carbon footprint summary report. Coffee production and processing in Costa Rica and Nicaragua. Reporte de consultoría. 8 p.

Attarzadeh, N y Noponen, M. (2010). Carbon footprint of coffee processing plant: Bencafe, Matagalpa, Nicaragua. Reporte de consultoría. Nicaragua. 5p.

CATIE. (2008) Propuesta metodológica para evaluación de servicios ambientales. Adaptado de Medina, Muñoz, Haggar y Aguilar- ANCAFE, 2006.

Cerdán, C., Soto, G., Vaast, P., DeClerck, F., Melo, E. & Sinclair, F. Local knowledge and perception of coffee growers on ecosystems services in the Volcanica Central Talamanca Biological Corridor, Costa Rica. 4p.

Chaluleu, C. (2010) Guía ilustrada Aves en cafetales con sombra de la subcuenca El Hato, San Agustin Acasaguastlán, El Progreso. CATIE-CIRAD-ANACAFE-DEFENSORES DE LA NATURALEZA.Guatemala.

Chaluleu, C . Monitoreo Biológico de Aves Residentes e implementación de Educación Ambiental dentro de la Subcuenca El Hato , San Agustín Acasaguastlán, El Progreso.

DeClerck, F.A.J. 2009. La conservación de biodiversidad en sistemas agricolas del Corredor Biologico Volcanica Central Talamanca. Freia de devolucion de informacion a productores cafetaleros. Turrialba, Costa Rica.

DeClerck, F.A.J. 2010. Contribución des Systemes Agro-Forestiers a la Conservacion de la biodiversite dans le corridor mesoamericain. Meeting of the ATP Omega 3. Montpellier, France.

DeClerck, F.A.J. and A. Martinez-Salinas. 2010. Mixing the Matrix: Participatory Avian Bioiversity monintoring withing the VCTBC, parks, pastures and coffee. Presented to USA Congressional Aides, Turrialba, Costa Rica.

DeClerck, F.A.J. 2010. Conservacion en la matriz Agricola del corredor biologico Volcanica Central Talamanca; Connectividad y Ritmos annuales. Associacion de Ornitologos de Costa Rica. San Jose Costa Rica.

DeClerck, F.A.J. 2010. Certification for Biodiversity. Presented to the Rhode Island Dept of Agriculture. Providence, Rhode Island.

DeClerck, F.A.J. 2010. Biodiversity Conservation and Ecosystem Function in Agricultural Landscapes. University of Rhode Island.

Del Cid Pérez, R.M.; Leonel Tot, C. (2008) Caracterización sub-cuenca El Hato- Reserva de Biosfera Sierra de las Minas- San Agustín Acasaguastlán, El Progreso, Guatemala.

De MELO, E. (2011). Principios generales y modelo valorativo de vulnerabilidad y adaptabilidad al cambio climático en fincas cafetaleras. UNA, AMBIENTICO, mayo, Costa Rica, 212: 7-9.

Estrada, N.E. 2009. Valoración del aporte de los SAF de café en la oferta de algunos SE de acuerdo a su arreglo espacial y tipología de manejo en el Corredor Biológico Volcánica Central Talamanca. Feria de devolución de información a productores cafetaleros. Turrialba, Costa Rica.

Faure et Le Coq J.F. (2009). Estrategias de las cooperativas cafetaleras frente a los sellos ambientales en Costa Rica. Informe en el marco del proyecto CAFNET, CIRAD UMR innovation, Montpelier, Marzo 2009, 65p.

Florian E. (2008). Caracterización del Sitio de Estudio: Zona cafetalera del Corredor Biológico Volcánica Central-Talamanca. Proyecto CAFNET. CATIE-CIRAD, Costa Rica.

Guitiérrez R. C. J. (2008). Conectando y sosteniendo los servicios ambientales para café agroforestal, Nicaragua: caracterización zona piloto peñas blanca. CATIE, CIRAD. Managua, Nicaragua, 47p.

Haggar, J. y Soto, G. (2010). Análisis del Estado de la Caficultura Orgánica. Consultoría para la Coordinadora de Comercio Justo en América Latina. Nicaragua. 60 p.

Haggar Jeremy., CAFNET: servicios ambientales y de mercados para café agroforestal.

Haggar Jeremy., (2006) Metodología para la evaluación de servicios ambientales, ANACAFE

Haggar Jeremy, (2008) COOMPROCOM R.L. Plan Estratégico Institucional (Revisión Julio 2008.

Hocde H. (2009) Estrategias de las organizaciones de productores de café frente a los sellos ambientales en la zona de la Reserva de la Biosfera de la Sierra de las Minas, Guatemala. Proyecto CAFNET, CIRAD, Marzo 2009, 80 p.

Hocde H., Le Coq JF (2010) Construcción de calidad de café en las cooperativas cafetaleras de Nicaragua. Estrategias de las cooperativas cafetaleras frente a los sellos ambientales en Nicaragua. Informe de misión de consulta del programa Cafnet. Cirad. Abril 2010, 32p.

INCAE, MINAET & CATIE. (2009)Memoria taller de expertos carbono neutralidad en el sector agrícola. 12 y 13 de febrero, 2009. CATIE, Turrialba, Costa Rica.

Jerez Gutiérrez, R.C. (2008). Caracterización Zona Piloto Peñas Blanca. Proyecto CAFNET. CATIE-CIRAD, Managua, Nicaragua.

Le Coq JF. (2010). Sellos y Cadenas de café en Guatemala. Informe sintético de misión del 30 de noviembre al 4 de diciembre 2009. PCP Sistemas agroforestales Centro America, Cafnet, Cirad Catie, 12p.

Le Coq, (2009). El desarrollo de los sellos en la agrocadena de Café en Guatemala, informe de mision PCP, dec 2009

Martinez-Salinas, A., Declerck, CF. Bird dynamics and use of coffee and cacao agroforests, silvopastoral systems, sugar cane and forest landuses in the Central Volcanic Talamanca Biological Corridor, Costa Rica.

Medaglia, J. C. Pago de servicios ambientales a sistemas agroforestales de café: posibilidades legales y conveniencia técnica. (2011) Revista Judicial, Costa Rica, n. 99, p. 69-93, marzo 2011.

Meylan, L., Gary, C., Merot, A. and Rapidel, B., (2010). Agroforestry coffee practices in relation to productivity and erosion control in the Pirrís watershed, Costa Rica, Agro2010, Montpellier, France.

Muñoz C. Y. (2010). Aproximación a la cadena de valor del café en Guatemala. Informe final. Proyecto Cafnet, Catie, Cirad, Anacafe, Fundacion defensores de la naturaleza, Noviembre 5 del 2010, 127 p.

Noponen MRA, Edwards-Jones G, Haggar J, Healey JR (in prep.) Getting REAL – intensification of coffee systems can increase the effectiveness of REDD+ mechanisms. En tramite para su publicacion.

Noponen, M. Healey, J. Edwards-Jones, G., Haggar, J., Soto. G. (2010). Coffee agroforestry systems in Costa Rica: carbon emissions vs. sequestration. SENRGY, Bangor University, Wales & CATIE, Costa Rica. Poster presented at Bangor University.

Pérez, R. M. C. (2008). Caracterización sub-cuenca el hato reserva de biosfera sierra de las minas san agustín acasaguastlán, El Progreso, Guatemala. Proyecto Cafnet, Catie, Cirad, Anacafe, Fundacion defensores de la naturaleza, Diciembro del 2008, 48p.

Programa de monitoreo de aves. Aves en paisajes agropecuarios de Centroamerica. http://web.catie.ac.cr/pma

Grupo de ganadería y manejo del medio ambiente (GAMMA) y Cátedra latinoamericana de ecología en el manejo de bosques tropicales, Aves en paisajes agropecuarios de Nicaragua y Honduras.

Simposio de biodiversidad y servicios ambientales en Guatemala. Libro de resúmenes. Noviembre 2010.

Roupsard O. (2010). La Plataforma Coffee-Flux : resultados 2008-2011 utiles para la finca Aquiares : agua, sedimentos, indice de area foliar. Presentacion powerpoint y discusion. Finca Aquiares.

Roupsard O. (2010). Curso de ecofisiologia para Rainforest Alliance: Carbono, agua, sedimentos, indice de area foliar. Curso powerpoint y gira de campo. Finca Aquiares.

Soto G., Le Coq J.F., De Melo E., Jones C., Faure G. (2010). Cooperativas caficultoras: Certificaciones, mercados y cambio climático. Potencialidades y perspectivas para enfrentar los riesgos de mercado y del cambio climático: Proyecto CAFNET, 28 y 29 de Octubre de 2010. Montpellier: CIRAD, 34 p.

Soto, G. (2009). Memoria del Taller de Análisis de la Caficultura Orgánica en Costa Rica. Octubre 2009. CATIE, Costa Rica.

Soto, G. (2009). Agricultura Orgánica como herramienta de desarrollo: ¿cuál ha sido el rol de la certificación en este proceso? Boletín RUTA.

Soto, G. y Quilo, A. (2009). Memoria del 2do Taller de Análisis de la Caficultura Orgánica en Guatemala. ANACAFE, Ciudad Guatemala, Guatemala.

Soto, G., Haggar, J., Barrios, M., Quilo, A. y Jerez, R. (2010). Análisis de la Crisis de la Caficultura Orgánica. Síntesis Talleres de Análisis realizados en Nicaragua, Costa Rica, Guatemala y Honduras. CATIE, Turrialba, Costa Rica. 24 p.

Virginio Filho, E. de M.; Abarca, S. M. (2008). Cafetales para servicios ecosistémicos, con énfasis en el potencial de sumideros de carbono: el caso de cooperativas cafetaleras afiliadas a COOCAFE Costa Rica. Informe final. CATIE, FUNCAFOR, COOCAFE, OIKOCREDIT. Costa Rica, Junio 2008, 61p.

Virginio Filho, E. de M.; Barrios M.; Toruño, I.M; (2009). ¿Cómo podemos mejorar la finca cafetera en la cuenca? Una guía de apoyo a procesos de reflexión-acción-reflexión participativas con familias productoras y promotores técnicos. CATIE. 1ª edición. Managua, Nicaragua, 72p.

Artículos en la prensa

http://www.nacion.com/Generales/Subsitios/AldeaGlobal/2011/DiaMundialdelAmbiente/NotasSecundarias/Subsitios2771021.aspx

http://www.nacion.com/Generales/Subsitios/AldeaGlobal/2011/DiaMundialdelAmbiente/NotasSecundarias/Subsitios2771047.aspx

http://www.nacion.com/Generales/Subsitios/AldeaGlobal/2011/DiaMundialdelAmbiente/NotasSecundarias/Subsitios2795151.aspx

Soto M. 2011. Como se sabe cuánto carbono captura un cafetal? El Periódico La NACION-Costa Rica, 5th of June 2011, San José.

CATIE. Mapeando puntos calientes de erosión y conservación de biodiversidad de los cafetos. Boletín electrónico n. 35. Enero-febrero 2009.

CATIE. Servicios ambientales en el sector cafetalero. Boletín electrónico n. 38. Julio-agosto 2009.

CATIE. Estudio del carbono almacenado en las plantaciones de café espera mejorar los medios de vida rurales. Boletín electrónico n. 41. Enero-febrero 2010.

CATIE. Expertos analizan cómo enfrentar el cambio climático en los cafetos. Boletín electrónico n. 44. Agosto-octubre 2010.

CATIE. El café, más que un cultivo. Boletín electrónico n. 47. Abril-junio 2010.

CATIE. Proyecto CAFNET deja huellas en Centroamérica, África del Este e India. Boletín electrónico n. 47. Abril-junio 2010.

CATIE. Un banco de semillas y plantas para el presente y el futuro mundial. Boletín electrónico n. 47. Abril-junio 2010.

Anexo 6. Lista de diferentes eventos realizados durante Proyecto CATIE-CAFNET-CIRAD / 2007-2011 (Centroamérica)

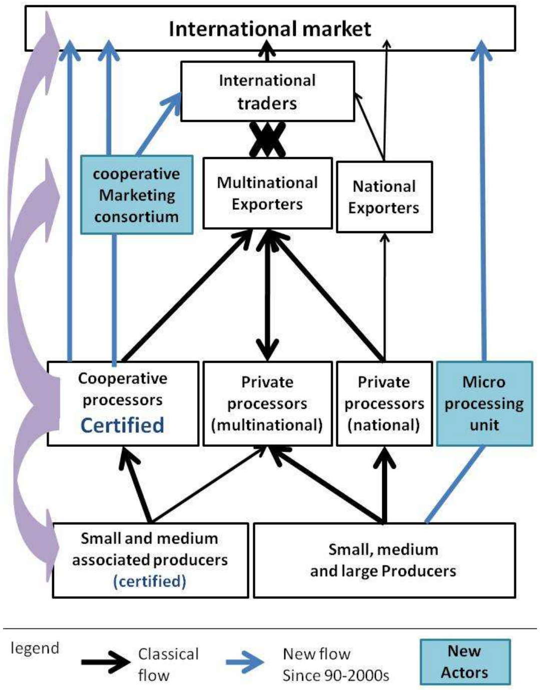
Nº	Fecha	Lugar/País	Evento	No. de participantes
1	14/05/2007	Oficinas de FONDAGRO, Matagalpa, Nicaragua	Reunión comité interinstitucional CAFNET Nicaragua	10
2	17/07/2007	Oficinas de FONDAGRO, Matagalpa, Nicaragua	Reunión comité interinstitucional CAFNET Nicaragua	12
3	31/10/2007	CATIE, Turrialba, Costa Rica	Reunión comité interinstitucional Costa Rica CAFNET	21
4	12/12/2007	San José - Costa Rica	Notas taller - rainforest alliance	7
5	11/03/2008	CATIE, Turrialba, Costa Rica	Reunión taller de selección fincaspiloto CAFNET	23
6	16/04/2008	Matagalpa, Nicaragua	Taller de validación agroforestal: intercambio experimentadores CAFNET y experimentadores JUCUAPA-FOCUENCA	17
7	24 y 25/06/2008	Matagalpa, Nicaragua	Programa taller deseño y manejo de sombra en cafetales CATIE-CAFNET-CIRAD	20
8	04/07/2008	CATIE, Turrialba, Costa Rica	Taller para seleción de fincas pilotos del proyecto CAFNET	26
9	07/08/2008	Matagalpa-Nicaragua	Reunión del comité tecnico CATIE-CAFNET Nicaragua	12
10	17/09/2008	San Pablo de Tres Equia, Turrialba, Costa Rica	Visitas al ensayo de sistemas agroforestales con café - CATIE, finca de José Angel y Flory Gamboa	47
11	17, 18 y 19/09/2008	Instalaciones de prodever, Guatemala	Fortalecimiento organizacional y acesos a mercados	22
12	23/09/2008	Salón pergamino, Anacafe, Guatemala	Conectando e sosteniendo los servicios ambientales y de marcado para café agroforestal CAFNET presentacion	20
13	23/09/2008	Oficina OTN CATIE, Guatemala	Reunión equipo técnica CATIE, CAFNET, ANACAFE y DEFENSORES	8
14	24/09/2008	Finca Los Bálsamos, San Agustín, El Progreso, Guatemala	Inauguración del lanzamiento oficial y taller introductorio local del proyecto CAFNET	27
15	16/10/2008	San Agustín Acasaguastlán, Guatemala	Reunión selección parcelas demonstrativas	10
16	21/10/2008	Beneficio Orlich-ECOM, Orosi, Costa Rica	Reunión de seguimiento fincas piloto CAFNET - Orosi	8
17	21/11/2008	San Agustín Acasaguastlán, Guatemala	Programa taller deseño y manejo de sombra en cafetales	15
18	17/02/2009	Guatemala	Reunión con ANACAFE	8
19	17/02/2009	Guatemala	Reunión con defensores en Guatemala	10
20	17/02/2009	Guatemala	Reunión con Byron Medina (PNUD) y Ministerio de Recursos Naturales y Ambiente	6
21	18/02/2009	San Agustín Acasaguastlán, Guatemala	Reunión en defensores	6
22	18/02/2009	San Agustín Acasaguastlán, Guatemala	Reunión con comite interinstitucional	9
23	19/02/2009	San Agustin-Guatemala	Reunión con Don Jesus Ramírez	6
24	20/02/2009	Guatemala	Reunión con Cesar Tot (defensores)	4
25	22/05/2009	Salón comunal del distrito Cachi, Paraíso	Red local de riesgo Cachi-CAFNET/CBVCT	10
26	04/06/2009	La casona del cafetal, Cashi, Costa Rica	Reunión red local CASHI-CAFNET	9
27	08/06/2009	Cluster de Orosi, Costa Rica	Fortalecimiento de la cadena de valor del programa de café sostenible AAA Nespresso	40
28	17/06/2009	Matagalpa, Nicaragua	Taller de seguimiento parcelas de validación y capacitación	7
29	19/06/2009	San Pablo de Tres Equia, Turrialba, Costa Rica	Visita intercambio finca piloto validación agroforestal - CAFNET grupo de cafeteleros de COOPEASSA	14
30	22/06/2009	Centro típico el rio, Quebradilla	Corredor biológico interurbano COBRI SURAC - Subcorredor Corralillo	35
31	22 a 26/06/2009	Costa Rica	Programa tentativo de la gira de servicios ambientales a Costa Rica: programa conjunto "fogarcli" efecto 4	12
32	17/07/2009	Sala Ceibo, INBioparque, Costa Rica	Segundo grupo focal: estado actual estrategias y planes de acción nacionales en biodiversidad	20
33	22/07/2009	Cashí, Costa Rica	Taller con produtores asistidos por ECON-Orosi	50
34	31/07/2009	Cachi, Orosi	Encuentro Cafetalero: Alianzas Estratégicas	20
35	26/08/2009	CATIE, Turrialba, Costa Rica	Taller de intecambio experiencias PSA-SAF-CAFE	19
36	23/09/2009	Restaurant La Mílpa, Cachí, Costa Rica	Desafio Cartago: carbono neutral	74
37	07/10/2009	Jardín Botánico, CATIE, Turrialba, Costa Rica	Estado del conocimiento del CBVCT, uniendo cordileras investigaciones en el corredor biológico Vulcánica Central - Talamanca	15
38	21/10/2009	Las minas, Guatemala	Taller se seguimiento parcelas de validación y capacitación	sinf
39	26/10/2009	Turrialba, Costa Rica	Taller de seguimiento parcelas de validación y capacitación	12
40	15/12/2009	Guadalupe, San José	Plataforma de certificación CATIE-CAFNET	6
41	24/03/2010	CATIE y Turrialba, Costa Rica	Intercambio con promotores y productores de ADDAC (Nicaragua) en visita a ensayos de sistemas	21
42	01/06/2010	CATIE, Turrialba, Costa Rica	Taller de grupo técnico especialista: módulo clima de la red de agricultura sostenible, criterios para la adaptación y mitigación al cámbio climático	13

43	07/07/2010	Finca Lucerito, Orosi, Costa Rica	Taller de intercambio validación agroforestal	25
44	21/07/2010	Bar y restaurant Coto, Oreamuno, Cartago, Costa Rica	Cambio climático, caficultura adaptación y mitigación	122
45	01/09/2010	Tarrazu, Costa Rica	Capacitación a produtores Ecom	80
46	28 y 29/10/2010	Heredia, Costa Rica	Taller: cooperativas caficultoras - certificaciones, mercados y cambio climático	43
47	25/11/2010	Matagalpa, Nicaragua	Taller final con experimentadores locales en validacion agroforestal	13
48	26/11/2010	Nicaragua	Taller final con organizaciones sociais de Nicaragua	16
49	03/12/2010	Edifício Anacafe, Guatemala	Presentación de resultadosproyecto CAFNET y experiencias similares en Guatemala y Centroamerica	15
50	25 y 26/05/2011	CATIE, Turrialba, Costa Rica	Taller centroamericano de cierre del proyecto CAFNET	56

CAFNET East Africa

2007 – 2011

Final Narrative Report



September 2011

F . PINARD

CAFNET East Africa Synthetic report.

CAFNET Partners in East Africa

ICRAF

CIRAD

NUCAFE

COREC

NAFORRI

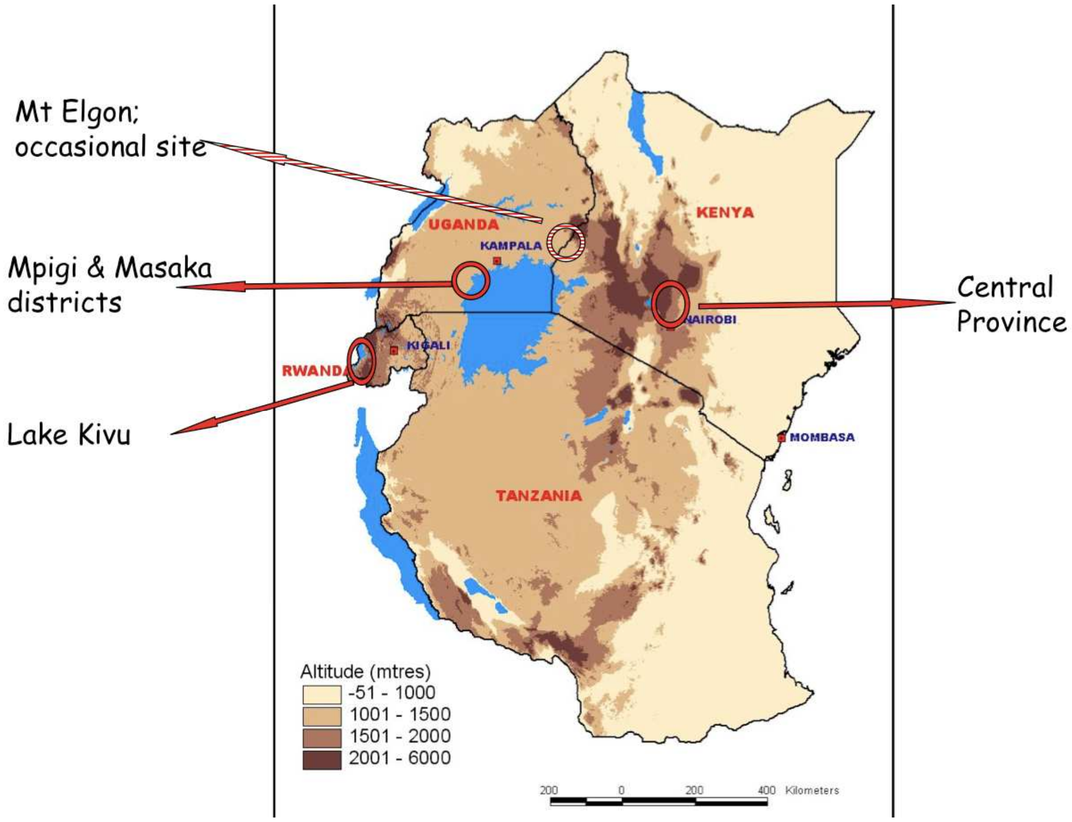
COOPAC

MUGAMA Cooperative Union

CRF

National Museum Kenya.

CAFNET sites in East Africa



CAFNET Participants 2007 / 2011.

Country	Name	Institution	Role
Rwanda	M. Ngendo	ICRAF	Team Leader – Gisenyi.
	Elidad UWIRINGIYIMANA	ICRAF	Technician – Gisenyi.
	Theoneste	ICRAF	Technician – Gisenyi.
	D. Kagoro	ICRAF	Team Leader – Admin – Kigali.
	G. Uwimana	ICRAF	Admin Assistant – Gisenyi
	F. Pinard	ICRAF	Scientist - Coordinator. (2009-2011)
	E. Rwakagara	COOPAC	Coordination Gisenyi
Uganda	Samson Gwali	NAFORRI	Lead Scientist/Coordinator (Ecologist/Tree diversity)
	Katumba Balikitenda	NAFORRI	Team Leader - Carbon study (Agroforester)
	Susan B. Tumwebaze	NAFORRI	Technical backstopping - Carbon study (Biometrician)
	Jude Sekatuba	NAFORRI	Team Leader – Livelihood study (Socio-economist)
	Isaac Kiyingi	NAFORRI	Team Leader – Profitability study (Resource Economist
	Moses Mbalule	NAFORRI	Team Leader – Soil study (Soil Scientist)
	Hillary Agaba	NAFORRI	Agroforester
	John Esegu	NAFORRI	Community livelihoods/Social Forestry
	Moses Basoga	NAFORRI	Technician – profitability study
	George Niyibizi	NAFORRI	Technician – soil study
	Paul Balitta	NAFORRI	Technician – livelihood study
	Bernadette Kabonesa	NAFORRI	Technician – carbon study
	David Muwonge	NUCAFE	Information dissemination - training
	Robert Musenze	NUCAFE	Information dissemination – training
	Sam Maganda	NUCAFE	Information dissemination – training
	Rashida Nakabuga	NUCAFE	Information dissemination – training
	Rose Namatovu	NUCAFE	Information dissemination – training
	Hassan Kakooza Mulagwe	NUCAFE	Information dissemination – training
	Henry Wasswa	NUCAFE	Information dissemination – training
	David Lukwata	NUCAFE	Information dissemination – training
	Charles Lubega	NUCAFE	Information dissemination – training
	Mark Kasule	NUCAFE	Information dissemination – training
	Joseph Nkandu	NUCAFE	CAFNET Project Coordinator Uganda
	Alex Samba	NUCAFE	Information dissemination - training
	Johannes Dietz	ICRAF	Scientific support – Carbone study
	Dr. Pascal Musoli	COREC	Principal scientist
	Saleh Nakendo	COREC	Scientist
Kenya	K. Kahlenbeck	ICRAF	Scientist – Biodiversity
	M. Nyabende	ICRAF	Scientist- GIS
	J. Wanjara	ICRAF	Assistant – GIS

	F. Sinclair	ICRAF	Scientific coordination (2010-2011)
	S. Yiapan	ICRAF	Admin support
	R. Onyango	ICRAF	Admin support
	N. Oseko	ICRAF	Accountant
	G. Lammond	ICRAF	Scientist – Traditional knowledge
	D. Mithoefer	ICRAF	Scientist – Economy
	F. Pinard	ICRAF / CIRAD	Scientist – Project coordination East Africa (2009- 2011)
	J.M. Boffa	ICRAF	Scientist – Project coordination East Africa (2007- 2008)
	A. Gassner	ICRAF	Statistic support
	E. Wanjohi	MUGAMA	Field operation coordination
	P. Mbataru	ICRAF	Information dissemination
	A. Kuria	ICRAF	Post graduate – Biodiversity
	E. Smith	ICRAF	Scientist – Traditional knowledge

Graduate Students

Kenya	E. Gathoni	ICRAF	PhD student – certification
K / Ug / Rw	A. Aithal	ICRAF	PhD student – Value chain
Kenya	S. Carsan	ICRAF	PhD student – Coffee AF system
Kenya	M. Montzieux	ICRAF	Master – farm typology
Rwanda	G. Bernardeau	ICRAF	Master – farm typology
Rwanda	A. Magné	ICRAF	Master – traditional knowledge
Uganda	A. Hummel	ICRAF	Master – traditional knowledge
Kenya	L. Elliott	ICRAF	Master – traditional knowledge
Rwanda	M. Bruno	ICRAF	Master – value chain
Rwanda	R. Nansamba	ICRAF	Master – traditional knowledge
Uganda	S. Nguyen Ba	ICRAF	Master – farm typology
Uganda	M. Ronald	ICRAF	Master – traditional knowledge
Kenya	E. Joetzjer	ICRAF	Master – Biodiversity
Kenya	K. Barkaoui	ICRAF / CIRAD	Master – systems functions
Kenya	J. Nyaga	ICRAF	Post graduate – systems function / disease
Kenya	M. Vorlaufer	ICRAF	Master – Economy / Value chain
Kenya	J.B. Leguet	ICRAF	Licence – Value chain
Kenya		ICRAF	Master – Pollination

It is commonly accepted that agroforestry based agricultural systems provide more diversified and more efficient environmental services than monoculture systems. These include soil protection, water control, biodiversity preservation and carbon sequestration.

In East Africa, CAFNET mainly focussed on the 2 latter and developed studies in Uganda, in the area surrounding the protected Mabira forest in Mukono District and Kenya, on both Aberdare Mountains and Mt Kenya.

1- Tree biodiversity.

Kenya: Mt Kenya. Two surveys of 182 (Annex EnvS 2) and 75 farms (Annex EnvS 4) were conducted in the area, generating quite similar results, although based on different sampling protocols: farm inventory in the first case, 0.1 ha plot sampling in the second one.

- The sample richness was high, reaching 162 species in the first survey and 180 in the second.
- A significant effect of altitude was detected, the higher zone being richer in tree species than the lower.
- The great predominance of 10 to 15 tree species, representing more than 80% of the total sample abundance.
- The over representation of exotic versus native species, *Grevillea robusta* being by far the most abundant species in the area.

More specifically, the 75 farm survey (Annex EnvS 4) highlighted the fact that coffee plots showed a reduced tree diversity and included more exotic species, while the 182 farm survey (Annex EnvS 2) pointed out that on farm tree abundance and richness could be controlled by indirect economic or social factors: it was noticed that within the farm sample, farmers with constant or increasing coffee production tended to retain more trees from more species than farmers with decreasing coffee production.

Kenya: Aberdare Mountains: Some 50 km SW of Mt Kenya, an additional survey was conducted on a sample of 61 farms to assess the Tree on Farm diversity (Annex EnvS 1).

The observed total richness was much lower than in Mt Kenya, with only 59 detected species. However, the same situation of a limited number of dominant species (18 in this case), mostly exotic and mostly *G. robusta* prevailed. No altitudinal gradient was detected in the sample, but a cluster analysis based on the density distribution of the most frequent species revealed the existence of 2 distinct farm groups: on the one hand smaller farms, with higher level of agroforestry practices and higher density of trees, and on the other hand, bigger farms with reduced tree density.

At farm level, the study pointed out the uneven spatial distribution of trees, more trees (richness, abundance) being observed in the fences and in the farmer's garden than elsewhere on the farm. In this respect, trees appeared to be less abundant and less diversified inside coffee plots.

Uganda: Mabira forest surroundings: In Uganda, 79 plots of 0.1 ha were investigated at various distances from natural or degraded forest patches, (Annex EnvS 3).

The survey detected 63 tree species, the native one being predominant (richness wise). As what it appears now to be a "usual" pattern, a limited number of species (*Artocarpus heterophyllus, Albizia chinensis,* etc.), mostly exotic, represented most of the tree abundance: 10 species only representing 81% of the observed tree population. Interestingly, the distance from the natural forest generated opposite gradient for richness and abundance: the tree species richness seemed to decrease with the distance, while the abundance increased.

These studies described the obvious advantage of agroforestry systems to preserve the tree biodiversity, when compared to monoculture system. Whether or not they favour the endemic tree preservation appeared to be a question much more difficult to answer. Native species are still found in the agricultural landscape, maybe more frequently in the studied area of Uganda than in Kenya. But their abundance is low, sometime very low, depending of the level of anthropisation of the system, responsible for the introduction and wide dissemination of exotic species (*G. robusta* in Kenya, *A. heterophyllus, A. chinensis,* in Uganda). The elimination of these rare species from the landscape is a possible risk difficult to evaluate from this work. At least 2 studies (Annex EnvS 1 & 4) mentioned that coffee plots did not appear as a favourable on farm site to reduce this risk, whereas fence and garden seemed to offer a better option for rare species preservation (Annex EnvS 1).

2- Carbon sequestration

Carbon (C) stocks, and ultimately carbon sequestration potential in coffee agroforestry systems (CAFS) has been in the focus of research for several years. Potential financial benefits for framers add value to such assessments, in order to quantify these benefits and analyze the viability of such approaches. Carbon stocks have been quantified for various CAFS particularly in Latin America, India and Southeast Asia, yet information from East Africa agro-ecosystems has been scarce.

To that end, CAFNET supported two activities since March 2010 in Central Uganda (Mabira) and Central Kenya (Murang'a) for detailed assessments of C stocks in the respective *robusta* and *arabica* CAFS, this to allow comparison of the 2 systems. It is worth mentioning that work on carbon in Kenya was conducted on the same farm sample used for the Aberdare biodiversity study (**EnvS 1**) and the tree on farm economic study (**ES 11**).

Indeed, the 2 systems expressed great differences regarding their carbon stocks: the Above Ground Biomass was significantly higher in Uganda – 21.6 t/ha (median)- than in Kenya – 13.8 t/ha (median)-. This result is not only explained by the greater quantity of carbon linked to trees on farm, but also by the quantity of carbon stocked in the coffee trees themselves - 5.6 t ha^{-1} in Uganda *vs* 1.2 t ha^{-1} in Kenya.

Reasons for these differences may be due to the farm organisation and the level of management of the AF system which greatly differ in the 2 countries:

- In Kenya, agroforestry products are managed according to a fast turn over which prevents the development of old, big size trees. Furthermore, the farm space is partitioned in several plots relatively poor in trees, dedicated to crops. Trees are unevenly distributed, being mostly concentrated in area like fence and garden. In such systems, the level of organization would appear relatively high.
- On the contrary, in Uganda, the agroforestry system appeared less controlled by human factor. Older, bigger tree are more numerous than in Kenya and disseminated within the farm: trees are scattered and not concentrated on specific structures like fence.

CAFNET in East Africa gave a relative emphasis to this area of research as it was assumed to be the main driver of the coffee agroforestry context in the region.

In 2007, when CAFNET was initiated, the coffee production sector in East Africa, and elsewhere as well, was devastated and pattern of production decline were frequently noticed in the region (abandoned coffee plot, switch to other crop, decline of yield and quality, loss of interest from the youth population, etc.). At this time, the general feeling was that coffee sector was at risk and no clear trend was giving direction for its future. If the coffee sector was threatened, what about the agroforestry system supporting it? If the trend of decline was to be confirmed, would that imply the end of the connected agroforestry system?

In the socio economic area, CAFNET aimed to answer these questions in the various contexts of Kenya, Uganda and Rwanda. Data were collected mostly from surveys and already existing data bases (secondary data). Analyses of such information were comparative or situation specific. As a complement to this approach, options of development like the adoption of new standards for example were critically questioned to assess their potential.

1- Context characterization.

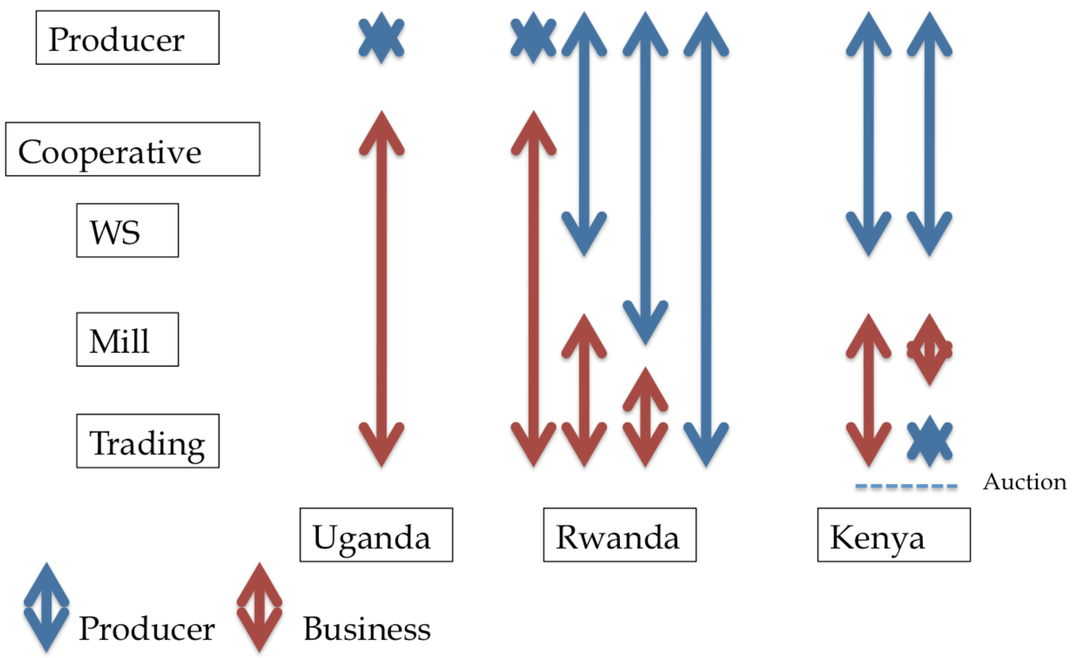
A descriptive analysis of the coffee value chains (CVC) was initially conducted to obtain a clear identification of the country contexts (Annex ES 1). These appeared to greatly differ in their various dimensions:

- Uganda CVC was the most stable, entirely liberalized, in the region, while Kenya and Rwanda CVC were still changing and adapting.
- Kenya recently (2006) terminated its auction monopoly selling system (unique in the region) which opens possibility of direct sells.
- Rwanda entered in 2004 only into a complete reorganization of the CVC toward the production of fully washed coffee and the building of numerous washing stations.
- The private sector controls the entire production sector in Uganda and it is likely to be the same situation in Rwanda.
- In Kenya, the process of vertical integration is building up although the traditional cooperative sector, unique in the region, remains strong and organized.

2- Typology and coffee revenue.

These patterns, summarized in Fig. 1 , reflect different dynamics resulting from various historical backgrounds and address different markets. Their direct comparison was therefore difficult to implement.

Fig 1: CVC structure in Uganda, Rwanda and Kenya



Farmers in Uganda and Rwanda seemed to secure small, but sustainable, profit from coffee cultivation, mostly because they did not invest on the crop (fertilization) (Annex ES 1). On the opposite, Kenyan farmers are frequently at loss because of the input cost (Annex ES 1; ES 11). Even when they break even with coffee, they rarely reached the level of poverty threshold which would ensure sustainability and attraction to the crop (Annex ES 2).

In this context, the agroforestry farming system appeared to gain an important economic dimension: it is a valid diversification option (Annex ES 11; ES 12) that could generate greater revenue than coffee (Annex ES 11). This situation, revealed by CAFNET, could lead to the definition of a new paradigm for coffee agroforestry: agroforestry system might no longer be seen as a consequence of coffee cultivation, (at least in Kenya) but rather the "driving engine" of the farming system because agroforestry product seemed more attractive financially. Such consideration is interesting to explore, especially for agriculture policy makers: if they want to address the poverty issue of the coffee farmers, promoting agroforestry could become an option as valuable – if not better- than promoting coffee production.

3- Coffee value chain efficiency.

In the current context, it thus appeared that the agroforestry system supporting the coffee production in East Africa may not be at risk as it is an important source of income preserved by farmers.

Therefore, one way to improve rapidly the global performance of the entire system appeared to improve the efficiency of the coffee component. With this respect, CAFNET implemented several study to locate sources of efficiency losses in the CVC and possible solutions.

3.1. Coffee value chain weak points.

Costa Rica coffee CVC is nowadays considered as a modern and performant example of CVC. When compared to Kenya CVC (Annex ES 4 & 5) and other CVC in East Africa, it revealed several characteristics that could explain the greater remuneration of Costa Rican coffee farmers:

- farmers in Costa Rica are offered the possibility to sell their cherry to competing private and cooperative washing stations,
- a national coffee market in Costa Rica offers attractive price to farmer,
- productivity in Costa Rica is high compared to East African context. Volume production generates revenues that compensate the loss of lower coffee price.
- The cooperative sector in Costa Rica is efficient and well organized.
- The entire value chain in Costa Rica gives a better quality reward to farmers.

Tentatively, studies were initiated in East Africa to assess the validity and the relevance of these indicators in the region.

In Kenya, a survey of the cooperative sector in the Central Province revealed that the main factors explaining the performance of cooperatives identified in our econometric analysis include indicators that reflect: (i) the alignment of members' goals with the goals of the cooperative and the prevalence of free riding, (ii) problems of mismanagement at the management level of the cooperative as measured by incidences of corruption, and, (iii) the transparency and stability of the cooperatives' marketing strategy. (Annex ES 3)

In Uganda, the CAFNET partner NUCAFE demonstrated the negative impact of the middlemen that capture a significant part of the product value (Annex ES 8). By improving the quality of the coffee production, mainly through a better process of the coffee, they were able to help farmers' groups to bypass the middlemen and to access directly to the exporters and sell at a better price. NUCAFE described the process as a "New Coffee Value Chain for Uganda".

During the course of CAFNET, Rwanda coffee value chain went through a major reorganization process, including a drastic shift in production strategy. In 2002, the Rwandese Gouvernment approved a new set of objectives and guidelines for the coffee sector, aiming at transforming the national production from 'standart' dry or semi-washed bean, to fully washed coffee. Indeed, the objective of the Gouvernment was to improve the general quality of the national production in order to generate greater revenues on the quality / specialty market. This implied the construction of numerous wetmills and the corporate organization of farmers in cooperatives association. During CAFNET implementation, the number of washing station operating in Rwanda increased from 2 to more than 120. Attemps were made to capture the dynamic of this move and to assess the ability of Rwandese actors to improve their revenue. Indeed, some initiatives were quite successful and the CAFNET partner COOPAC cooperative was one of the actors that demonstrated a quite high efficiency in accessing the international market. But many other actors were not as successful, for reason not necessarily due to a lack of efficiency. As examples, one can mention the sell and bankruptcy of Rwanda main exporter –Rwandex- at that time owned by the Gouvernment (2009), or the development of export taxes on green coffee. Therefore, in this transitional period of adaptation and evolution of the production sector in Rwanda, when the situation was not yet settled, we abandoned the objective of making conclusive and valid remarks about the Rwandese coffee value chain.

3.2. Coffee standards and eco-certification.

A sustainable trend in the international market is the increasing importance of eco-certification. These eco-labels or standards allow access to the better-remunerated market of specialty coffee and are therefore an interesting marketing option to improve farmers' revenue. But it also assumed they could have a positive impact on the environment and could favour or promote agricultural systems such as agroforestry, assuming that it is more environmental friendly. With this respect, it is assumed that eco-certification would be a valuable option to address at once poverty issue and sustainable development.

In East Africa, CAFNET worked to establish the validity of these 2 assumptions.

Preliminary investigation analysed the recent development of the new coffee standards in the region (Annex ES 5). A detailed analysis of the Kenyan context showed that the development of eco-certification was initiated in 2005 and, nowadays, only involved a very limited number of cooperatives and farmers. In this context, an impact assessment of eco-certification on environment was impossible to conceive, as the initiatives were too recent to have any visible influence on the environment.

Another way to assess the standard potential to impact the environment was to conduct a critical analysis of the criteria they impose and to assess their importance and relevance (Annexe ES 9 & 10). The study confirmed the main focus of the standards not only on environment issues but also the social ones; less importance seemed to be given to the economic domain. Most generally, environmental issues were addressed through specific recommendation (biodiversity preservation for example), but it was noticed that they were always associated with more common "Best Agricultural Practices" consideration. Incidentally, the study revealed the high level of homogeneity of the compared standards: Faire Trade, Utz, 4C, Organic, RFA, CAFÉ PRACTICE, Bird friendly and Nesspresso. If they differ, it is generally not according to the quality of the imposed criteria, but rather to the number of criteria.

The early stages of development of the eco-certification in East Africa offered an interesting opportunity to study the dynamic of the process and to capture some of its fine mechanisms. With this purpose, 2 studies were implemented in Kenya and in Uganda. None was developed in Rwanda as the same, juvenil stage of eco-certification was seen only on the developing fully washed (see supra) and the effects of the 2 factors on the farmers' revenue could not be separated.

In Kenya (Annexe ES 5 & 7), surveys always revealed a strong "top-down" approach initiated by actors outside the farmers' community i.e. the private exporters. Somehow, the initiative always appeared to be imposed to farmers' groups, or at least part of it, in a context of reduced dialogue. Such situation frequently generated conflicts within farmers, or between farmers and the cooperative management, leading in one case to the split of the farmers' community.

In Uganda, the initiative to obtain a 4C certification was supported by a farmer Union (NUCAFE) (Annex ES 12). Although external to the community, NUCAFE could be considered to be closer to the targeted farmers' group than a private exporter. As the community was smaller than the one considered in Kenya, information dissemination did not appear as a major problem and direct support to farmers could be better achieved. The situation leads to the certification of the group and a rapid access to improved revenue to farmers.

Documentation about coffee agroforestry practices in East Africa is poor when compared to the situation of Latin America where a large amount of published information is readily available. In Kenya, Rwanda and Uganda, the number of publications is small and crucial information, about shade impact for example, is still missing.

CAFNET aimed to fill this gap and implemented various studies in the 3 countries in order to generate some base line information from the regional context. With this purpose, several field trials and surveys were initiated.

In Rwanda, with the participation of 50 farmers, a field trial was implemented mainly to capture the shade impact on coffee productivity and quality. Complementary information includes shade tree species-specific impact, soil biodiversity and soil composition (Annex AfP 1).

In Kenya, on the slopes of the Aberdare Mountains, a one year trial involving 15 farms proposed a statistical spatial method to characterize the agroforestry context at farm plot level. It also generated valuable information about shade influence on coffee yield and coffee disease (Annex AfP 2). Implemented on the Mt Kenya area, another study based on a farm survey brought information on soil erosion within the coffee agroforestry area (Annex AfP 3).

In Uganda, in the specific context of Robusta coffee, a shade trial involving a unique farm generated observations about coffee yield and quality (AfP 4), pest (Annex AfP 5), disease (Annex AfP 6) and soil (Annex AfP 7).

Main Results

1- Yield

In Uganda, on Robusta coffee, no shade influence on yield could be detected, nor on coffee quality. The results confirmed the high yield potential of one variety (1 S/6) out of the four tested. (Annex AfP 4).

In Kenya and Rwanda, on Arabica coffee, detailed observations revealed the positive impact of shade that increased production. In Rwanda (Annex AfP 1), shade impact fluctuated between years, but generated an overall 35% production increase over 4 years. An analysis of the coffee bean size distribution revealed the reduced occurrence under shade conditions of the lower quality, small bean and therefore provided indirect evidence of the positive impact of shade on quality in the trial environment. In Kenya (Annex AfP 1), the annual gain of production under shade appeared to vary between 10 to 20% and it is interesting to notice that the benefit was higher in intermediate level of shade than with low or too high shade environment.

2- Pests.

The shade influence on coffee pest was only assessed in Uganda by a team led by COREC scientists. The work from S. Nakendo (Annex AfP 4) indicated that the global level of pest incidence was reduced under shade condition. But this result seemed to conflict with more detailed observations including specific observations of 7 insect pests including coffee berry borer (CBB) (*Hypothenemus hampei* Ferrari), black coffee twig borer (BCTB) (*X. compactus* Eichoff), coffee leaf miners (CLM) (*L.eucoptera spp*.), coffee leaf skeletonisers (CLS) (*E. dohertyi* Warr.), coffee berry moth (CBM) (*P. smaragdina* Butler), canopy mealybugs (CM) (*Planococcus kenyae* Le Pelley), and green and helmet scales (SC) (*Coccus spp*. and *Saissetia coffeae* Walker). (Annex AfP 5). This study could not detect any specific shade impact on all pests except one: the BTB *X. compactus* which incidence is increased under *Albizia chinensis* canopy. This might be due most probably not because of the shade generated by the tree, but rather because the tree is a possible alternate host of the insect. Incidentally, the study also revealed the higher level of resistance to BTB of the coffee variety 236 S/26.

3. Diseases.

In Uganda, the study includes *Hemileia vastatrix* (CLR) and *Cercospora coffeicola* responsible for leaf spot and red blister (on fruit) (Annex AfP 6). Conducted during 7 months, the trial failed to detect any impact of shade on the diseases incidence.

In Kenya, CLR and CBD were assessed during the CBD incidence pick, in May and June 2010 (Annex AfP 2). The shade impact on CBD damages varied with the altitude: at higher altitude, above 1500 m, shade reduced by nearly 30% the disease impact; the incidence reduction was only by 10% at lower altitude. The study also revealed the positive impact of shade on CLR but in a complex manner: when coffee was grown on the southern side of the valley (facing North), shade reduced only the severity of CLR. On coffee facing South, shade reduced not only the severity of the disease, but also its incidence.

4. Soil.

The survey from Mt Kenya (Annex AfP 3) is a global characterization of the soils from the agroforestry coffee growing areas. Based on a NIRS analysis of 189 soil samples, the study revealed the global deficiency of the soil mainly in organic carbon, total nitrogen and probably phosphorous. It also confirmed the very low quantities of manure and fertiliser application rates.

A more detailed study conducted in Uganda (Annex AfP 7) analysed the soil texture and soil composition according to the distance from 2 different tree species: *Ficus natalensis* and *Albizia chinensis*. The data indicate that there were generally higher nutrient levels, pH, organic matter, calcium, and potassium under shade tree species of *Ficus natalensis* and *Albizia chinensis* than in the open including the level of pH.

In Rwanda the production/shade trial included soil chemical and texture analysis and soil diversity assessment (bacterial)(Annex AfP 1). Results indicated that when Sun and Shade treatment are compared, no difference are detected for C, N, pH, Diversity (H index), Minerals, Sand and Clay, but, an impact is detected on Silt content with higher content under shade (p value = 0.0009953). Within the shade treatment, Carbon, Nitrogen and Silt content are influenced by the nature of the shade tree species, the leguminous nature of the species being most probably the reason why such effect. Finaly, the trial suggested a possible effect of tree species on bacterial diversity, close to signification (p value=0,071), which needs confirmation.

This specific task of CAFNET was implemented in close collaboration with farmers' groups from the 3 countries: NUCAFE in Uganda, MUGAMA Cooperative Union in Kenya and COOPAC in Rwanda. Through this critical partnership, it is believed that the CAFNET activities have reached an important number of farmers estimated to 25000 in Uganda, more than 15000 in Rwanda and 140000 in Kenya.

With collaborators, CAFNET generated and disseminated information about the respective national coffee context (price, organization…) and agroforestry systems (practices, trees characteristics, etc). In the 3 countries, these activities were complemented with nursery support, seedling dissemination and training. It is worth mentioning that in Rwanda, until January 2010, CAFNET activities were developed in collaboration with USAID and ACDI VOCA through a joint participation to the Lake Kivu shade coffee project.

1. **Information dissemination.**

Uganda: the booklet "Farmer Ownership Model" (Annex Diss 1) was developed by NUCAFE in Uganda and used for training. Generally the training content included Value chain building to enhance farmers' market value share, group dynamics for better governance and management of farmers' associations and GAPS (Biodiversity conservation ownership). Initially published in English, the guidelines have been translated into Lingala and disseminated to farmers group of Massaka, Mpigi and Mukono Districts.

As a training aid and also for data collection a video documentary entitled "CAFNET project professionalising coffee farming was made"

Kenya: information was mostly disseminated through a monthly newsletter "Kahua nia biacara" (Annex Diss 2) published in Kiswahili. The newsletter was brought to the 54 coffee cooperatives of the Mugama Union for a period of 22 months. It included general information about the Kenyan Coffee sector (politic, market, events…), case studies like a comparison between auction and direct sales or day-to-day information of the cooperatives sector activities. The newsletter also provided technical advises on coffee agronomy and agroforestry practices.

Rwanda: In two districts nearby Gisenyi town (Rutsiro and Rubavu Districts), CAFNET contributed to the edition of 8 factsheets about shade trees providing information about origine, planting and seedling production, pruning and harvest product when available (Annex Diss 3), published in Kinyarwanda and disseminated to more than 500 coffee farmers.

2. **Training.**

Training has been an important component of the activity and was implemented at various levels, with various categories of local actors.

Uganda: 3675 farmers, including about 30% of women, received direct training by NUCAFE about AF practices and coffee value chain (Annex ES 8). The training was extended to 50 extra staffs: Trainers of Trainees and field assistants- in the 3 concerned districts (Massaka, Mpigi and Mukono).

Rwanda: CAFNET contributed in 2009 and 2010 to the training and sensitization of:

- local authorities, including Mayors (2), cell and sector Secretary (33), Chef de Village (75) and local agronomist (6);
- Farmers; 1604 of them received direct training by ICRAF and COOPAC staffs about agroforestry practices.

Kenya: Training was more centralized and limited to nursery practices. The training was dedicated to the Mugama Union staff involved in the nursery work, at the Union farm of Maragwa, this to support the revival of the Union nursery activities.

3- Nursery activity.

During CAFNET implementation, it was generally found that farmers were very receptive to agroforestry ideas and that they were very keen to adopt/extend agroforestry practices. The demand for trees was always high within the community involved in the implementation of CAFNET and very frequently not matched because of the lack of seedling availability. Therefore, CAFNET developed the nursery activity on a participatory basis as a key tool to favour the dissemination of agroforestry ideas and practices within the farmers' population and to answer the farmers' expectation.

Kenya: CAFNET supported the revival of the tree nursery activity of the MUGAMA Union. The general scheme of development envisaged was a central nursery, hosted by the Union farm in Maragwa, aimed to provide seedlings to a network of secondary nurseries that would ultimately sell the seedlings to farmers.

In this regard, Union staff received specific training about nursery practices and a program of rehabilitation of the structure was designed and implemented, leading to the building of seed beds, shaded growing areas, water storage point and irrigation system. To initiate the process of seedling production, MUGAMA Union received from ICRAF seed bank more than 10000 seeds of 5 tree species.

Uganda: NUCAFE extended its support to farmers groups by supporting nurseries activities. In 2008 and 2009, it facilitated the creation of 14 nurseries to produce seeds (more than 7 kgs) and seedlings.

Rwanda: the nursery support became a major activity targeting a mass dissemination of seedlings. With this purpose, 80 nurseries implemented by farmers were created aiming at the production of more than 1 million seedlings from 8 trees species with the following main tree usage: fuel wood, timber and board; mulching, sticks and anti erosive barriers.

Specific usages:

- *Alnus acumiinata*: shade
- *Cedrella serrata*: shade
- *Entandrophragma excelsa: medicinal…*
- *Leucaena diversifolia: fodder; progressive terrace, shade*
- *Calliandra calothyrsus: fodder; progressive terrace*
- *Maesopsis eminii: addible oil, shade*
- *Polyscias fulva: mortar and barrel; shade*
- *Inga spp (paipai): shade*
- *Grevilea robusta: board used for boat construction, shade*
- *Ficus thonningii: mortar and barrel; shade*

	Disseminated seedlings
Alnus acumiinata	
Carapa grandifolia (local)	
Cedrella serrata	279139
Entandrophragma excelsa (local)	
Leucaena diversifolia	232915
Maesopsis eminii	28493
Polyscias fulva (local)	60745
Inga spp (paipai)	53821
Calliandra calothyrsus	277548
Grevilea robusta	73984
Ficus thonningii (local)	20000
Total tree produced	**1,026,645**
Total trees disseminated	986675
% Disseminated	*96,1*
Total farmers	8023

Table n° 2: Summary, per tree species, of the seedlings disseminated to farmers in 2009 / 2010.

The dissemination was initiated by ICRAF staff in November 2009. It was later implemented and controlled by the farmer in charge of the nursery. The distribution was terminated in December 2009.

This organization was proven efficient due to the effective mobilization of the project collaborators and the efficient campaign of sensitization organized to inform farmers: most of the trees produced (96.2%) could therefore be distributed to a quite large number of farmers: 8023 (Table 2).
Most of farmers received some 144 to 209 trees of the various species.

Discussion on the nursery – dissemination activity.

1. Through direct farmer support, the project demonstrated the possibility to organize a high-density nursery network, producing a high number of seedlings: more than 1 million in this case.
2. The approach is innovative and efficient. Its total cost of 50000 USD leads to a unit coast per seedling of RwFr 27 (1$ @ 540 RwFr), which is very much acceptable when compared to other known cost in the region, between 30 to 40 RwFr.
3. We estimated that a minimum of 8000 farmers received trees from the project. Assuming that all of them are coffee farmers, they represent altogether a little bit less than 25% of the coffee farmers of Rubavu and Rutsiro District.
4. Each of them received trees that were mainly used on coffee plots like *Alnus, Cedrela serrata, Leuceana div., Maesopsis, Paipai* and *Polyscias fulva* for mulching, fodder, anti erosive barriers and shade. But they were also used in non-coffee plot. This indicates that the project was not only a support to coffee agroforestry but also a broader support to general agroforestry practices.
5. From previous census, it was estimated that each coffee farmer in the region possesses an average of 130 coffee trees, on an area of 0,052 ha i.e. 520 m2. Therefore, it can be estimated that a little more than 450 ha of coffee have been impacted by the project.
6. It is obvious that the project also impacted non-coffee area, which currently cannot be estimated.
7. The project was terminated in December 2009. The only figure available at that time was the number of disseminated trees, not the numbers of planted and/or surviving trees. These ones will be assessed in 2010. Two distinct surveys are purposely planned for this.

i. A small scale survey in March 2010, after the planting season, estimated the number of tree effectively transferred to the field; Results suggested a transfer rate close to 100% (96%), thus revealing the high level of farmers commitment

ii. A larger survey, in September and October 2010, estimated the rate of surviving trees, after one year. More than 75% of the disseminated trees were still in the field after this period, confirming the high level of commitment from the farmers, and the correctness of the project objective.

Role of Remote Sensing and Geographic Information System (GIS) in CAFNET Project Activities: A case study of Mapping Coffee Growing Areas in Kenya, Rwanda and Uganda

Meshack Nyabenge

Background

With closely similar agro-climatic conditions, three selected countries either grow Arabica or Robusta coffee under different farming practices. Kenya dominantly grows Arabica coffee under both industrial (large scale plantation) and mixed agricultural systems (small scale), Uganda is known for Robusta coffee grown under shade of agriculture mixed systems and limited plantations, while Rwanda grows Arabica coffee, which is dominantly in less than 1 hectare of farms with other agricultural systems.

The diversity in coffee growing systems in these targeted countries call for different approach to mapping. However, conventional satellite remote sensing data processing procedures like radiometric correction, unsupervised and supervised classification were adopted for each country mapping process (Lillesand and Kiefer, 2000; Sabins, 1997; Gonzalez and Wintz, 1977; Anderson et al, 1976). Similarly, acquisition of training sites used a combination of data sources like google hosted images (available Quickbird images) and landuse\landcover data from Africover. In specific, the following extra post-processing methods were adopted per country based on coffee growing systems available. These would yield to basic landuse and landcover products that have direct bearing to coffee growing systems practiced in each country.

Linking these coffee related landuse\cover layers with other relevant information on coffee growing and production systems in each of the three countries within GIS environment led to a nearly real coffee growing areas. The resultants maps were used to quantify coffee growing areas by systems per country, which is an important component in CAFNET project input for activities planning and monitoring. Attempt to link coffee growing system with tree cover percentage was tested to help in understanding of agroforestry based coffee growing systems, but it never yielded a positive outcome due to ambiguity in percentage range definition to fit coffee systems.

Methodology

Mapping of coffee growing area landuse types and other landcover in selected sites within the three countries adopted 2 keys procedures as remote sensing processes (image acquisition, radiometric corrections, unsupervised and supervised classification, and post-processing), GIS data processing and manipulation (suitability analysis, mix and matching data).

Remote sensing processes

- **Image acquisition**- Targeting both ASTER and Landsat images, a **GoeVIS** (internet based) tool for searching and ordering of Landsat and ASTER images in the satellite images archives (http://glovis.usgs.gov/) was employed. To cover all coffee growing areas within CAFNET project sites 9, 10 and 14 ASTER image scenes for 2007/2008 covering Kenya, Rwanda and Uganda were identified, ordered and acquired. Samples of Landsat images covering same study areas within the same time were freely downloaded to supplement data.
- **Radiometric correction** (also referred to as "pre-processing" and "restoration") was used to modify image digital (DN) values in order to account noise due to atmospheric interferences and date differences without affecting spatial and spectral status of information held in an image. In the study, radiometric correction was undertaken using Fast Line-of-sight Atmospheric Analysis of Spectral Hypercube **(FLAASH)** in ENVI version 4.6 and the resultant images were made available for subsequent processes for all ASTER and Landsat images.
- **Unsupervised classification** as a process of interpreting and analyzing of satellite images without operator's input was employed to get and understand natural clustering of landscape elements. The unsupervised classification was performed to all 9, 10 and 14 ASTER images scenes, one at a time so as to support selection of areas with homogenous landscapes properties, which was needed for training sites selection and supervised classification activities. Of major interest were areas of coffee, water bodies, natural forest, urban, bareland and other crops cultivation at large scales. In this process, natural forest, tea, and water bodies displayed clear homogenous-spectral characteristics (see figure 1 as a case example in Kenya) and could be quickly pulled out for training sites selections.

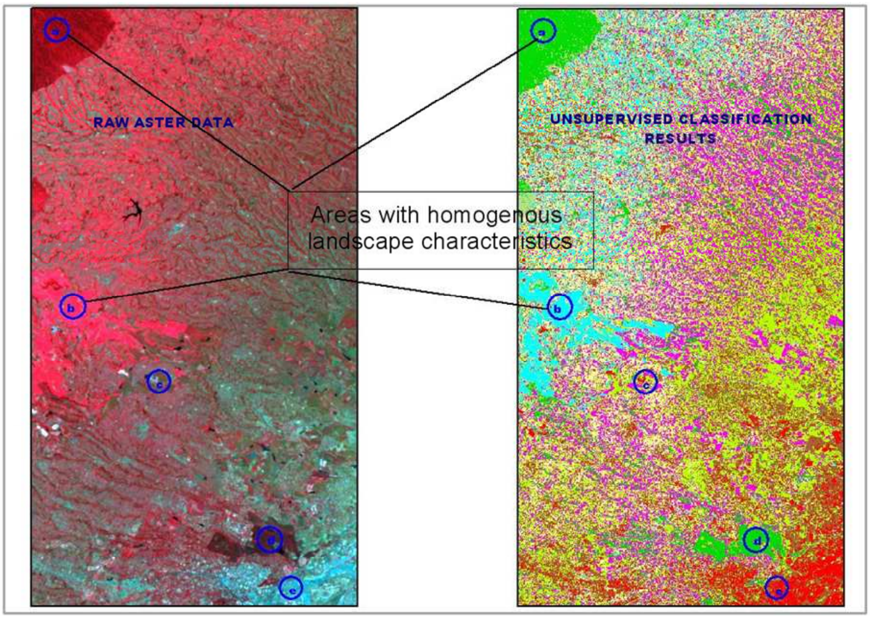


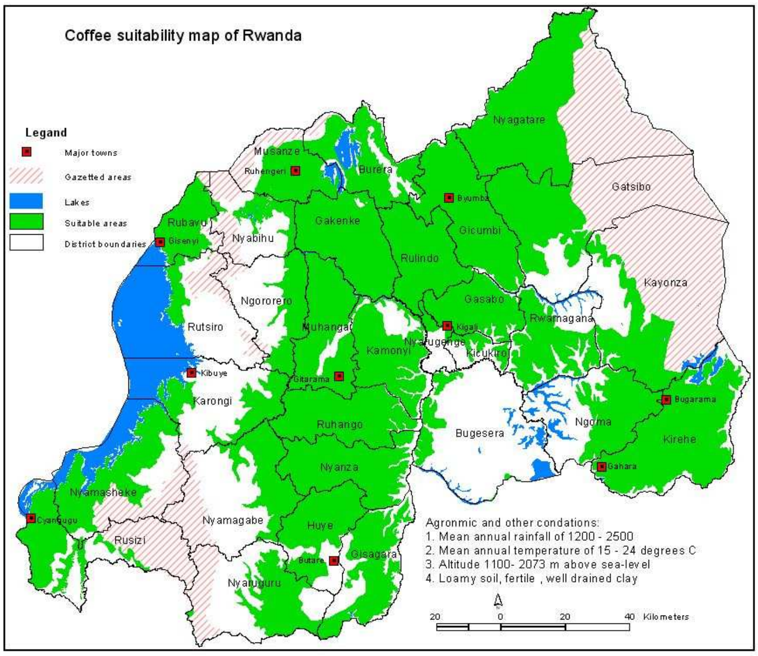
Figure 1: Raw ASTER Image & Unsupervised classification product (example from Kenya Study area)

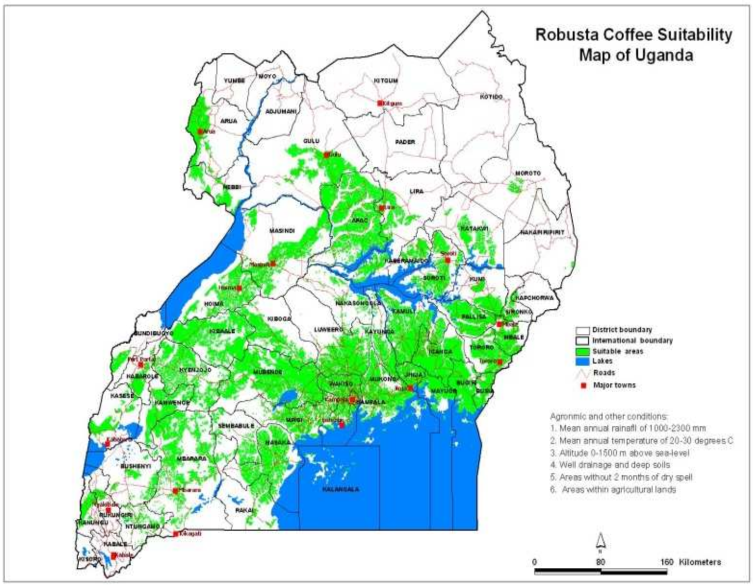
- **Training sites** were identified and captured from each radiometric corrected image using unsupervised images and series of data sourced from auxiliary data from fieldwork, clips of Quickbird images in Google Earth, and DRSRS crop data of 1997, and respective AFRICOVER databases for Kenya, Rwanda and Uganda. With Area Of Interest (AOI) tool from ENVI, samples of training sets for individual class were captured several times from each scene. Where necessary, a subclass training site selection was adopted in areas with minor variation per class, for example forest could several closely related reflectance values. These were captured under forest1, forest2, forest3, etc and later combined during data post processing.
- **Supervised classification** is a process where image analyst "supervises" the selection of spectral classes that represent patterns or land cover features that the analyst can recognize. With good training sites captured per scene from above mentioned activity, a classifier called "**Maximum Likelihood**" a classification tool in ENVI package was adapted in a supervised classification process because it is potentially the most accurate classifier as it incorporates the most information (mean vector and COV matrix) (Lillesand and Kiefer, 2000). Once all scenes were classified, then they were mosaic together to form one full scene and any error resulting within overlaying areas were manually corrected based on original images.
- **Post processing** -Most classifications have a problem with "salt and pepper", i.e., single or small groups of mis-classified pixels, as they are "point" operations that operate on each pixel independent of its neighbors. It is sometimes recommended to filters using "majority filtering" to replace central pixel with the majority class in a specified neighborhood (3 x 3 window); This "majority filtering" tool alters edges eliminating clumps "like" pixels and replaces clumps under size threshold with majority class in local neighborhood. It is due to this error that this study adopted manual post processing method to minimize unnecessary pixel changes, which could results in different information.

GIS Processes

- **Suitability Modelling** Entails to matching agronomic characteristics of coffee with its biophysical and socio-economic requirements to map areas where coffee is likely grow under rainfed scenarios. Does not physically confirm coffee existence on the landscape, and therefore can be used with data to predict coffee growing area. Does not respond to coffee growing systems, but reliable information for zeroing detail mapping process with high resolution satellite images. In case soil variables (pH, depth, and drainage), rainfall, temperature, altitude and areas outside gazetted lands from national geodatabases were captured and reselected based in coffee agronomic condition, which was merged under GIS Boolean Model approach (Bell, 2005), resulting in the map below (figure 3, example from Rwanda and

Uganda). This process was repeated for Robusta coffee growing areas in Uganda.





Figures 3: Arabica and Robusta Coffee suitability maps for Rwanda and Uganda respectively

- **Mix and Match Mapping** entails to selecting more than 2 of related coffee mapping initiatives from intensive to non-intensive methods using data from sourced from fieldwork to production information and combining them in GIS environment to improve on coffee mapping areas. Depending on layers available for each country, mix and match mapping was performed in all these sites giving different levels of outcomes. This method was employed in

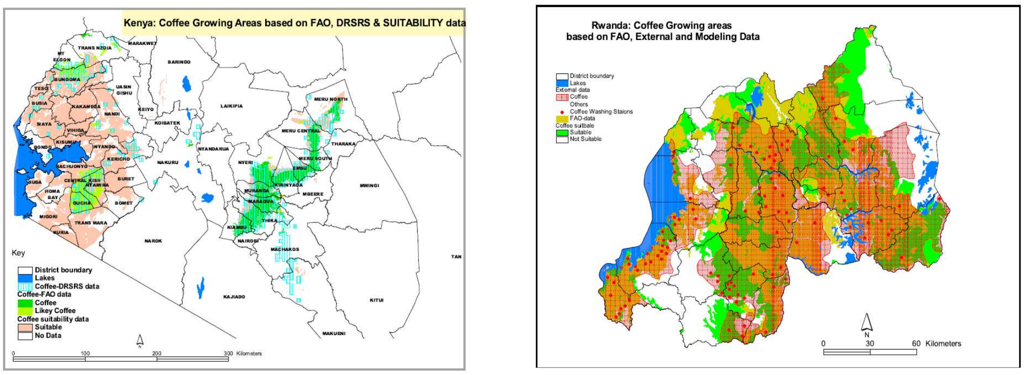
CAFNET project sites because of lack of resources to acquire enough Quickbird images or undertake intensive fieldwork to verify landscape elements from ASTER images to support mapping of the whole study sites

RESULTS AND DISCUSSION

Each applied process (RS or GIS) generated data and information relevant to CAFNET project activities. The products include general landcover data based on ASTER images generated per CAFNET sites in Kenya, Uganda and Rwanda as shown below (figure 4) and can be used to relate coffee growing systems with other shade based systems like clustered forest system within coffee growing area proximity aiding quality fruit fertilization.

With mix and match output, coffee growing areas are refined to help in quantification and analysis coffee growing system per country and be further refined using sample Quickbird or Ikonos images. See maps below generated from mix and match process (figure 5).

This process was performed for Kenya and Rwanda only because there no enough auxiliary data from Uganda.



Figures 5: Coffee growing areas based on mix and match process in GIS environment

References

1. **Anderson J. R , Hardy E.E, Roach T.J, Whitmer (1976).** A Land Use and Land Cover Classification System for use with remote sensor data. Geological Survey Professional Paper 964, United States Government Printing Office, Washington. US
2. **Camille C D and Lelong D (2001)** Note on the use of remote sensing imaging for CIRAD_AMIS, Montpellier, France, 2001 (http://clelong.chez.com/RSfeasibility.pdf)
3. **Clark B. and Pelikka P. (2007). Mapping land cover change in the Taita Hills, Kenya, utilizing multi-scale segmentation and object-oriented classification of SPOT imagery.** Geoscience and Remote Sensing Symposium, 2007. IGARSS 2007. IEEE International Volume , Issue , 23-28 July 2007 Page(s):1918 - 1921

4. **Balonos Sandra 2007**, Using Image Analysis and GIS for coffee Mapping, Department of Geography, McGill University, Montreal, Canada.
5. **Cordero Sancho S. and Sader S.A 2008, Spectral analysis and classification accuracy of coffee crops using Landsat and a topographic-environmental model, International Journal of Remote Sensing ,**Volume 28 , Issue 7 (March 2007)- Pages 1577-1593
6. **Lillesand T.M and Kiefer R.W. (2000)**. Remote sensing and image interpretation. Fourth Edition. John Wiley & Sons. New York.
7. **Moody A, Woodcock C.E. (1995).**The influence of scale and the spatial characteristics of landscapes on land-cover mapping using remote sensing. *Landscape Ecology,* 10: 363-379
8. **Sabins F. F. (1997).** Remote Sensing: Principles and Interpretation W.H. Freeman and Company, New York.
9. **Sancho C.and Sader S.A (2007). Spectral analysis and classification accuracy of coffee crops using Landsat and a topographic-environmental model. International Journal of Remote Sensing.** Volume 28 , Issue 7 (March 2007)
10. **Woodcock C.E., A.H. Strahler (1987).** The factor of scale in remote sensing. *Remote Sensing of Environment*, 21:311-332.

Using local knowledge about tree attributes to drive decision support tools to promote tree diversity on coffee farms in East Africa

Fergus Sinclair, Genevieve Lamond, Emilie Smith, Ronald Muchelo and

Anja Gassner

Abstract

Documentation of local knowledge about impacts of trees on coffee productivity and ecosystem services in Kenya, Rwanda and Uganda led to the identification of many tree species valued by farmers and a few key tree attributes, related both to utility and impacts on the coffee agroecosystem, that farmers used to decide on suitability of trees for integration with coffee. A generalisation survey involving more than a hundred farmers at each of the sites across the three countries, was then conducted to obtain farmers' rankings of tree species for each of these key attributes, as well as, information about fruit and leaf phenology. This resulted in a complex dataset of context specific local knowledge about attributes for a wide range of tree species. This local knowledge was then combined with scientific data and expertise in the Caftree decision support tool that helps to promote tree diversity on coffee farms.

Introduction

Previously, attempts to enhance tree cover on farms have tended to concentrate on one or a few 'best bet' species thereby mitigating against retention of tree diversity. Recent interest in a broader range of ecosystem services emanating from farmed landscapes and the biodiversity that underpins them has led to an urgent imperative to promote the retention of tree diversity on farms. A key bottleneck in achieving this, has been the scant scientific information available about most of the native tree species that may be utilised by farmers in any particular locality. To fill this gap we sought information from farmers about tree attributes and combined it with scientific information in decision support tools to promote tree diversity on farms.

Methods

Initial work was carried out in Kenya (2007 and 2009), Uganda (2008) and Rwanda (2007 and 2009) that documented agroecological knowledge held by coffee farmers at the CAFNET pilot sites in these countries using the AKT5 methodology and knowledge based systems software. These studies, detailed in the Bangor technical report for CAFNET, elucidated the main drivers for farmers to integrate trees with coffee and the impact that different tree species had on coffee productivity, biodiversity, soil and water.

Analysis of the knowledge bases revealed that farmers retained many different tree species on their farms, though most at low frequency, and that there were a few key attributes that farmers used to evaluate the suitability of tree species for integration with coffee. These included utility attributes such as firewood quality and timber durability as well as attributes affecting how trees interacted with coffee productivity and the agroecosystem more generally (e.g. crown density. leaf decomposition rate)

A generalisation survey, using a large stratified, random selection of interviewees, was conducted in 2010-2011 to collect farmers ranking of trees for these attributes. A total of 191 farmers were visited in Murang'a District, Kenya; 154 farmers in Rutsiro and Rubavu Districts, Rwanda; and 210 farmers in Mukono District, Uganda. Trees that farmers were asked to rank were selected according to their abundance and distribution in coffee farms across the local landscape, based on information generated from the previous local knowledge and tree inventory studies. There were 28 tree species included in the Kenya survey, 20 in Rwanda, and 18 in Uganda.

The trees were ranked by farmers against 12 physical attributes identified during the initial local knowledge studies. Phenology information was also gathered in a separate exercise; this was focused on timings of flowering, fruiting and leaf fall. This was not a preference ranking exercise but ranking for specific attributes, such as rooting depth. Depending on site conditions and location, a deep *or* a shallow rooting tree might be more or less preferable. During data collection, the gender and location of the farmer were recorded, along with GPS coordinates for each farm. Tree information cards (Figure 1) were used to get farmers to rank trees (up to 10 at any one time) that they were familiar with, in respect of each of the 12 different attributes (Figure 2). The data were analysed using a Bradley-Terry model to determine consistency of ranking and separation of ranks amongst species.

Results

The generalization survey generated 36 graphical representations (Figure 3) of ranks and their statistical separation (that is, for twelve attributes in each country, with the number of species ranked depending on how knowledgeable farmers were about different species for particular attributes). The results revealed firstly, and most importantly, that for many attributes farmers were able to consistently rank many species, although there tended to be a considerable number of middle ranking species that were not statistically different from one another. There were differences in how consistently an individual species was ranked for different attributes and how many and how consistently species were ranked for individual attributes. The data generated, including dates of flowering, fruiting and leaf duration complemented available scientific data and reinforced the findings from the initial knowledge acquisition.

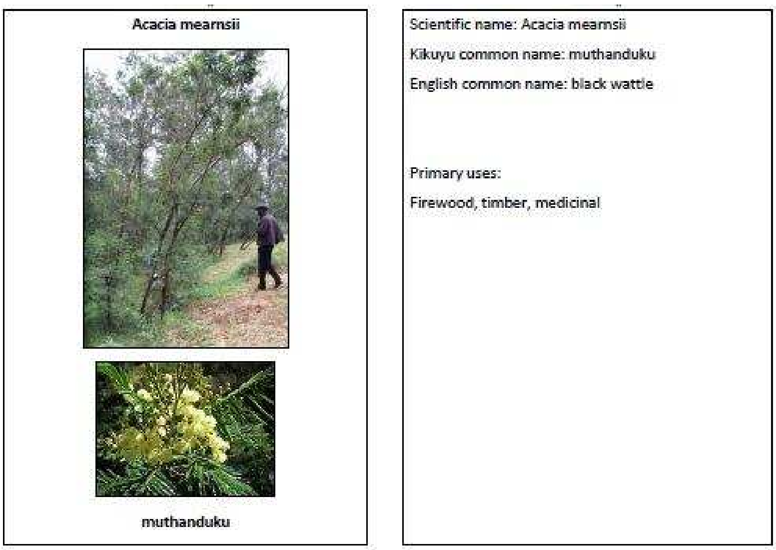


Figure 1. Example of a tree information card used during ranking and phenology exercises.

Figure 2. Carrying out the ranking exercise in a) Kenya b) Uganda and c) Rwanda

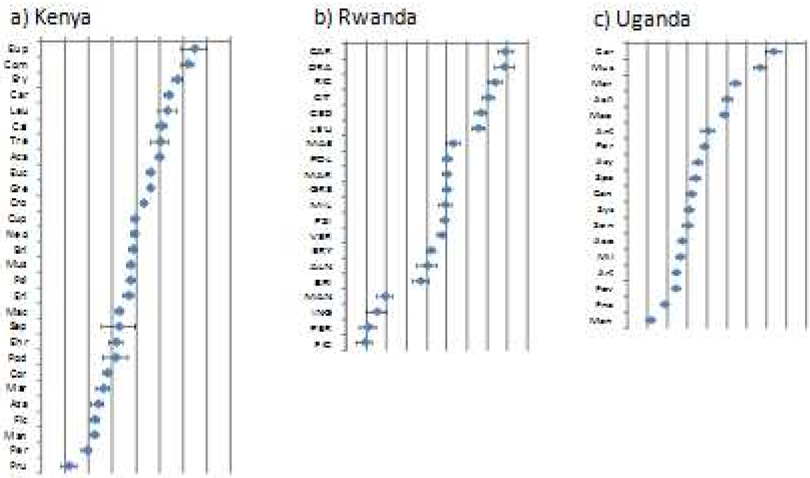


Figure 3. Graphical representation of farmer ranking for crown density of 28, 20 and 18 species in a) Kenya, b) Rwanda and c) Uganda respectively. Species within a graph whose error bars do not overlap are ranked statistically differently from one another.

For example, in Rwanda, trees were identified from the initial knowledge acquisition as playing an important role in soil fertility improvement. Trees with high leaf biomass were preferred because they reduced the need to mulch, suppressed weed growth and released nutrients quickly after leaf litter decomposition. Farmers' knowledge indicated that leaf biomass was linked to foliage density and deciduousness of the tree but distinguished differences in nutrient contribution and valued fast leaf decomposition because of the quicker nutrient recycling. Ranking for soil benefits of mulch showed that two species clearly distinguished themselves as providing most benefits, *Inga oerstediana* an introduced shade species, and *Ficus thoningii* a deciduous native species propagated by farmers. These trees had large and dense crowns and were often pruned or lopped and mulch transferred to other parts of the farm. *Erythrina abyssinica, Alnus acuminata* and *Persea americana* were also ranked highly with respect to soil fertility benefit and above other recently introduced trees such as *Grevillea robusta, Polyscias fulva* and *Leucaena diversifolia. Cedrela serrata* an introduced deciduous tree, was ranked low but this was probably an artefact of the relatively young age of the trees in the study locality that were not yet producing a significant amount of leaf biomass. The good quality and quantity of mulch provided by *Persea americana,* coupled with fruits which were important for nutrition, justified its inclusion in the coffee plot despite its high competitiveness for water and nutrients.

Discussion and conclusion

Farmers' ranking of trees in terms of different attributes important for their inclusion on coffee farms has created largely complementary data to that available scientifically. The farmer data is largely consistent and covers species for which there is scant scientific information and, importantly, evaluates the trees in the context for which decisions on their inclusion on coffee farms are being taken. The data are complex but can be readily housed within a decision support tool to promote tree diversity on coffee farms. Caftree (see Bangor CAFNET technical report) is a pilot decision support tool developed by the CAFNET project that combines farmer raking data on attributes with scientific data (the AgroforesTree database at ICRAF) and expertise, to produce options of tree assemblages and management guidelines customised to local circumstances.

Caftree is designed so that users input local information about their circumstances (ecological conditions and socio-economic objectives) and the tool generates options of relevant suites of species that meet these needs. A number of external criteria can also be selected for use (such as complementary fruiting times amongst the suite of species selected, either per farm or for a number farms across a landscape, to improve the animal biodiversity supported by the trees).

The methodology developed for acquiring and interpreting tree attribute ranks from farmers is novel and can now be more generally applied. ICRAF has adopted both the tree attribute methodology and the Caftree decision support tool approach and will continue to develop, test and apply these widely in their research and development work with national partners on coffee agroforestry in East Africa and beyond.

ANNEXES

ANNEX 1: Composition of steering committees

<u>Rwanda</u>:

Coopérative pour la Promotion des Activités Café : COOPAC
Ministère de l'agriculture,

REMA: Rwanda Environment Management Authority,

OCIR Café: Office des Cultures Industrielles du Rwanda, Département Café.

ICRAF.

<u>Uganda</u>:

Coffee Research Centre: COREC

National Union of Coffee Agribusinesses and Farm Enterprises: NUCAFE:

National Forestry Research Institute: NAFORRI

Uganda Coffee Development Authority: UCDA

ICRAF.

<u>Kenya</u>:

MUGAMA Coffee Cooperative Union

Coffee Research Foundation (CRF)

Institut Français de Recherche en Afrique: IFRA

Coffee Board of Kenya: CBK

ICRAF.

ANNEX 2:

LIST OF DOCUMENTS PRODUCED by CAFNET in EAST AFRICA

(all these documents are provided in pdf on a separate CD)

Scientific and technical reports for Promotion of Agroforestry Practices

AfP 1- **Influence of shade tree on Arabica Coffee Productivity and Quality in Rwanda.** F. Pinard, J.M. Boffa, M. Nguendo, Elidad, COOPAC, E. Muema and D. Lesueur.

AfP 2- **Effet des systèmes de culture agroforestiers paysans sur l'incidence des maladies cryptomgamiques (CBD, CLR) et sur la production de café dans la region de Murang'a au Kenya.** Barkaoui K.

AfP 3- **Determining soil nutrient indicators for intensive smallholder coffee systems of eastern slopes of Mount Kenya.** Sammy Carsan

AfP 4- **Determining Influence of Trees Shade on Robusta Coffee Productivity and Quality in Uganda.** Saleh Nakendo.

AfP 5- **Shade and Varietal Effects on Diversity and Prevalence of Insect Pests of Robusta Coffee in Central.** Kucel, P., J.P. Egonyu, G. Kagezi and P.C. Musoli

AfP 6- **Effects of Shade on Robusta Coffee (*Coffea canephora*) Diseases: A case study of coffee leaf rust (*H. vastatrix*), leaf spot and red blister (*C. coffeicola*).** Matovu J.R, A. Kangire and P. Musoli

AfP 7- **The effect of tree shade on soil properties in Robusta coffee in Uganda.** M.P.E. Wetala, A. Nambuya and A. Kangire

AfP 8- **Determining influence of tree shade on Robusta coffee productivity and quality, disease and insect infestation in Uganda.** Musoli P., Wetala, P., Nabaggala, F. Pinard and Kangire A.

Scientific and technical reports on environmental Services

EnvS 1- **Are Kenyan coffee agroforestry systems suitable for *circa situ* conservation of indigenous tree species? A case study from Muranga, Central Kenya.** Fabrice Pinard, Emilie Joetzjer, Katja Kehlenbeck

EnvS 2- Indigenous and exotic tree species richness in smallholder coffee systems of Mount Kenya: Implications for maintaining biodiversity in farmlands. Sammy Carsan.

EnvS 3- Tree Species Diversity and Abundance on Smallholder Coffee Farms around Mabira Forest, Uganda: Summary of key findings. Samson Gwali, Hillary Agaba, Paul Balitta, David Hafashimana, Joseph Nkandu, Fabrice Pinard, Anne Kuria and Fergus Sinclair.

EnvS 3b- Tree species diversity and abundance in coffee agroforests around Mabira forest system of Uganda. Samson Gwali, Hillary Agaba, Paul Balitta, David Hafashimana, Joseph Nkandu, Fabrice Pinard, Anne Kuria and Fergus Sinclair.

EnvS 4- Does Smallholder Coffee Farming Modify Tree Species Richness and Composition around Mt. Kenya? Anne Kuria, Katja Kehlenbeck and Fergus Sinclair

EnvS 5- CAFNET Carbon Analysis in East Africa. Johannes Dietz

EnvS 6- NAFORRI (Ug) CAFNET FINAL REPORT (Carbon Study component

Scientific and technical reports on Sociology & Economy

ES 0- Introduction: Economic analysis of coffee production and marketing in Kenya. Dagmar Mithöfer, Fabrice Pinard, Edith Gathoni Kirumba, Miriam Vorlaufer

ES 1- Can good coffee prices increase smallholder revenue? Aithal A. and Pinard F.; 2008; Cahiers d'Outre – Mer, Vol. LXI, 381- 400.

ES 2- Enjeux et perspectives du café dans les agricultures familiales de la region du Mont Kenya. Mémoire de fin d'étude; ISTOM; France; 2009. M. Montzieux.

ES 3- An analysis of the performance of Kenya's coffee cooperative societies. Vorlaufer, M., Pinard, F., Wollni, M., Mithöfer, D. (Master thesis under preparation). University of Göttingen and World Agroforestry Centre. (final results available by August 2011).

ES 4- Coffee sector efficiency and equity: lesson learned from a comparative commodity chain analysis of Costa Rican and Kenyan coffee sector. PINARD Fabrice, LE COQ Jean François, AITHAL Anand. (ASIC 2010)

ES 5- The raise of eco-label coffee: a comparative study of their effects on Costa Rican and Kenyan cooperative coffee sector. Le Coq J.F., Pinard F., Kirumba E., G. Soto (ASIC 2010)

ES 6- Effects of Coffee certification on smallholder farmers' livelihoods in Kenya. Kirumba et al. (in preparation, completed by Oct 2011)

ES 7- Unequal Participation of Smallholder Coffee Farmers in Coffee Certification Programs in Kenya. Kirumba, E.G, Mithoefer, D., Gassner, A., Pinard, F **(***Publication submitted***)**

ES 7b- Governance and participation of smallholder farmers in coffee certification programs in Kenya). Kirumba, E.G., Mithoefer, D, Gassner, A, Pinard, F (under review: Journal of Development Studies.)

ES 8- NUCAFE (Ug) CAFNET FINAL REPORT.

ES 9- Comparative analysis of coffee eco-certification initiatives. Pinard F., Kirumba E. (ASIC 2010)

ES 10- A comparative analysis of coffee ecocertification schemes and implications for agricultural extension services. Kirumba, E.G. and Pinard F. (Under review: Journal of Agricultural Education and Extension).

ES 11- Tree on farm economics: How and how much does agroforestry benefit smallholders coffee farmers in the Aberdare (Kenya)? Joetzjer E., Kehlenbeck K., Pinard F. (under preparation).

ES 12- NAFORRI (Uganda) CAFNET FINAL REPORT (Socio-Eco component)

Documents dessiminated to farmers

Presentations and minutes of steering committees and national workshops or forums:

1. Presentations at the 3rd all CAFNET workshops in Kenya, August 2009
   a. Session on Best Practices: 2 presentations
   b. Session on Biodiversity: 3 presentations
   c. Session on Certification: 2 presentations
   d. Session on Hydrology and Carbon sequestration: 4 presentations
   e. Session on Traditional Knowledge: 7 presentations
   f. Session on GIS & Upscaling: 3 presentations
   g. Session on Value Chain: 3 presentations
2. Presentations at the CAFNET East Africa final workshops in Kenya, March 2011
   a. Day 1 Afternoon on Biodiversity and Carbon : 6 presentations
   b. Day 1 Morning on Best Practices: 9 presentations
   c. Day 2 Afternoon on Value chain & Certification: 7 presentations
   d. Day 2 Morning on Livelihoods: 4 presentations
   e. Session on Traditional Knowledge: 2 presentations
3. Farmer ownership model; NUCAFE, Uganda, 44p.
4. Examples of Coffee Newsletter: Coffee agroforestry, prices & value chain (Kahũa nũ mbeeca) published monthly by ICRAF for 22 Months and distributed to farmers of 53 cooperatives in Kenya.
5. A total of 8 “Tree facts sheets”: dissemination material to coffee farmers of Rwanda in Kinyarwanda language.

ANNEX 3: Theses of graduate students

3 doctoral students

12 Masters students

<u>PhD Theses</u>

AITHAL Anand ; 2011 : **Coffee Value Chains and Farming Systems in East Africa: An Analysis of Efficiencies and Income Generation**. Doctorat de Geographie, Université Toulouse Le Mirail ; Dpt. Dynamique Rural. 25 Fevrier 2011.

E. GATHONI KIRUMBA: **Coffee eco labels and sustainable rural livelihoods: an analysis of coffee eco certification schemes in the Mt Kenya region.** Université Bordeaux III M. de Montaigne, Dept. de Géographie Tropicale, France (*To be defended in September 2011*).

CARSAN Sammy : **Sustainable smallholder coffee systems : the rôle of genetic ressources inputs and value chain systems. Faculty of Natural and Agricultural Sciences, University of the Free State. South Africa.** (*To be defended in 2011*).

<u>Masters</u>

Montzieux M. 2009. **Enjeux et perspectives du café dans les agricultures familiales de la region du Mont Kenya.** Mémoire de fin d'étude; ISTOM; France

Vorlaufer, M., Pinard, F., Wollni, M., Mithöfer, D.; 2011: **An analysis of the performance of Kenya's coffee cooperative societies.** (Master thesis under preparation). University of Göttingen and World Agroforestry Centre. (final results available by August 2011).

Barkaoui K. 2010: **Effet des systèmes de culture agroforestiers paysans sur l'incidence des maladies cryptomgamiques (CBD, CLR) et sur la production de café dans la region de Murang'a au Kenya.** Mémoir de fin d'étude Ingénieur agronome: ENSAM Montpellier, 2010. France

Hummel A. ; 2009: **Biodiversity, Ecosystem Services and drivers for change: Local knowledge on ecological interactions in shaded coffee agro-ecosystems surrounding Mabira Forest Reserve, Uganda**. *Master of Science* (MSc) International Natural Resource Development University of Wales Bangor. Feb 2009.

Magné A. ; 2008: **Agronomics, economics, socials and politics impacts of shade tree in coffee plots, in the region of Lake Kivu – Rwanda**. Rapport d'ingénieur ISTOM, France.

Lamond G. ; 2007: **Local knowledge of biodiversity and ecosystem services in smallholder coffee farms in Central Province, Kenya**. *Master of Science* (MSc) International Natural Resource Development University of Wales Bangor. Sept. 2007.

Bernardeau G. ; 2007: **Environmental and livelihood functions of trees and their management in coffee agroforestry landscape of lake Kivu, Rwanda.** Rapport d'ingénieur ENSAM, France.

Elliott L. ; 2009**: Farmers' Perceptions about the Utilities of Trees Associated with Coffee Farms in Central Province, Kenya**. Master degree of: Sustainable Tropical Forestry (SUTROFOR) Erasmus Mundus Program Master of Science (MSc) in Agroforestry. School of the Environment and Natural Resources Bangor University, Wales.

Nansamba R. ; 2009 : **Local knowledge about trees and ecosystem services in coffee plantations in Rubavu and Rutsiro districts, Rwanda.** Master degree of: Sustainable Tropical Forestry (SUTROFOR) Erasmus Mundus Program Master of Science (MSc) in Agroforestry. School of the Environment and Natural Resources Bangor University, Wales.

Bruno M. ; 2009: **Dans le cas des cultures de rente, comment l'exportation peut-elle contribuer à améliorer la participation des petits producteurs à la chaîne de valeur? *Le cas café au Rwanda*.** Mémoire d'ingénieur; ISTOM; France

Nguyen Ba S. ; 2009: **Le Coffee Wilt Disease, un espoir pour le café ougandais?** Mémoire de fin d'étude; ISTOM; France; 2009.

Joetzjer E; 2011: **L'agroforesterie dans les fermes café de Murang'a (Kenya) :** Entre diversité et rentabilité : Vers la promotion des systèmes agroforestiers les plus rentables comme alternative aux cultures de café en déclin. Mémoire d'ingénieur; ensaia – Université de Nancy; France

ANNEX 4: Publications

Articles published in International journals

AITHAL A. et PINARD F. ; 2008 : C**an good coffee prices increase smallholder revenue?** *Les Cahiers d'Outre-Mer,* 2008, n° 243, p. 381-402.

Articles published in proceedings of Conferences

Oral Communication

Aithal A.T.; Pinard F. 2009: **Smallholder Farmer Survival Strategies in Agroforestry-Arabica-Coffee Farming systems of East Africa.** Second World Congress of Agroforestry - August 2009 Nairobi, Kenya.

Le Coq J.F.[1,3], Pinard F.[1,2], Kirumba E.[2,4], G. Soto[3], 2010. **The raise of eco-label coffee: a comparative study of their effects on Costa Rican and Kenyan cooperative coffee sector.** ASIC Conference. 3-8 Oct. Bali, Indonesia.

Pinard F.[1,2], Kirumba E. [2,3]. 2010. **Comparative analysis of coffee eco-certification initiatives.** ASIC Conference. 3-8 Oct. Bali, Indonesia.

Poster:

Montzieux M, Pinard F, Sibelet N, 2009. **Agroforestry a means to achieve economic sustainability for smallholder coffee production in the Mount Kenya Region** [Poster] In: 2nd World Congress of Agroforestry, 23-28 August 2009, Nairobi, Kenya. - s.l. : s.n., 2009, 1 p.

Nguyen Ba S, Fourny G, Pinard F, Sibelet N, 2009. **The integral role of trees in coffee systems coping with coffee Wilt Disease: Case of smallholders in Mukono District, Uganda** [Poster] In : 2nd World Congress of Agroforestry, 23-28 August 2009, Nairobi, Kenya. - s.l. : s.n., 2009, 1 p.

Miriam Vorlaufer, Dagmar Mithöefer, Meike Wollni1, Fabrice Pinard ; 2011 : **Determinants of Collective Marketing Performance: Evidence from Kenya's Coffee Cooperatives**. Tropentag, October 5-7, 2011, Bonn.

PINARD Fabrice[1,2], LE COQ Jean François[1,3], AITHAL Anand. 2010. **Coffee sector efficiency and equity: lesson learned from a comparative commodity chain analysis of Costa Rican and Kenyan coffee sector**. ASIC Conference. 3-8 Oct. Bali, Indonesia.

Articles submitted

Samson Gwali, Hillary Agaba, Paul Balitta, David Hafashimana, Joseph Nkandu, Fabrice Pinard, Anne Kuria and Fergus Sinclair; 2011: **Tree species diversity and abundance in coffee agroforests around Mabira forest system of Uganda**. Submitted to Agroforestry Systems.

Kirumba, E.G.* [1] Mithoefer, D.[1] Gassner, A.[1] Pinard, F.[1]: **Governance and participation of smallholder farmers in coffee certification programs in Kenya**. Submitted to the Journal of Development Studies.

Kirumba, E.G.* [1], Pinard, F.[1]: **Towards simplified extension: A comparative analysis of coffee eco-certification schemes.** Submitted to Journal of Agricultural Education and Extension.

ANNEX 5

RWANDA main events.

11-29 September 2007 Sensitization meetings on roles of agroforestry in coffee systems in Rutsiro and Rubavu districts, 539 farmers trained.

5 November 2007, Project Stakeholder Day: Meeting on project complementarity: CAFNET (EU) and Lake Kivu shade coffee (USAID), presence of Minister of Commerce, USAID Mission director, DG OCIR-Café, DG REMA.

30 jan – 14 feb 2008 dissemination monitoring visits in Nyamyumba, Kivumu and Kigeyo sectors; Sectors Nyamyumba Kivumu Kigeyo. Villages Busoro Burushya Nganzo Karambi Kabere Buhindure Nkora

26 Feb – 19 March 2008: Farmer sensitization sessions on agroforestry tree management in coffee systems in Rutsiro and Rubavu district. Sectors Nyamyumba Kivumu Kigeyo. Villages Busoro Burushya Nganzo Karambi Nkora Buhindure Male Participants : 203. Female participants: 64. Total 267 participants

14-20 August 2008 Training workshop for trainers on pre-germination, raising and management of *Alnus acuminata*, as well as avocado and mango fruit tree management The two-day workshop was held on 19-20 August at the Stella Maris paroisse in Gisenyi.

17-29 April 2009: 1st training on the proper conduct and management of nurseries:

Zone	Village	date	Number of parcipants		Total
			Man	Woman	
Kivumu	Kivumu	17/04/2009	9	2	11
Kigeyo and Mushonyi	Nkora	21/04/2009	12	2	14
Boneza and Musasa	Bushaka	23/04/2009	7		7
Nyamyumba	Busoro	29/04/2009	8		8
Total			36	4	40

May 2009: 2nd training on the proper conduct and management of nurseries:

Date	Zone	Village	Nursery name	Nurseryman occupier
7/5/2009	Kivumu	Kivumu	1. Kabirizi (ICRAF) 2. Mitako (ICRAF) 3. Kibande 4. Kinyampudu 5. Gatare 6. Gikombe 7. Bugirwa 8. Rukurazo 9. Ruvominka 10. Nyamuhimba	HABUMUREMYI Syldion Miruho Faustin Nyiransekuye Clémentine Kayitesi Dansila Higaniro Paulin Hakizimana Placide Nahimana Obed Ntawukiriwabo Celeman Ntawigira Théoneste Harindintwari Erneste

Date	Zone	Village	Nursery name	Nurseryman occupier
8/5/2009	Kigeyo and Mushonyi	Nkora	1. Rucamahembe 2. Kanyirahweza 3. Nyakagezi 4. Gataretare 5. Cyimbiri 6. Kabikambuto 7. Bajyambere 8. Kibirizi 9. Muhora 10. Bugina 11. Nkora (ICRAF) 12. Kivumu 13. Nyagisozi 14. Kiraro	Nzimenyera Théoneste Ndererimana Nzanyamahoro Damascène Tahimana Grégoire Nsengiyumva Audace Kampire Uwihoreye André Nsabimana Evariste Uwingabire Aziza Ugirashebuja Joseph Bavakure Jean Damascène Rirwanabose Emmanuel Munyagikari Xavier Mandiwimfura Athanase

Nkora meeting point

Date	Zone	Village	Nursery name	Nurseryman occupier
20/5/2009	Boneza et Musasa	Bushaka	1. Cyirorero 2. Bwinyana 3. Bwesambanda 4. Bweramana 5. Bushaka 6. Nsinga 7. Karukamba	Nsengimana Rugambwabiri Fabien Nayigizente Félicien Mwiseneza Xavier Murekezi Jean Bosco Sebasaza Raphael Hakizimana J.M.V

Date	Zone	Village	Nursery name	Nurseryman occupier
21/5/2009	Nyamyumba	Busoro	1. Koha 2. Kazibira 3. Nyaruhonga 4. Gahinga 5. Kinyamunzirwa 6. Nyaruhonga 2 7. Mukondo 8. Gateko 9. Nyamwenda	Bagragaza Fabien Mbonyinshuti Bernard Rubanda Silvère Hategekimana Jean Nemejimihigo Laurent Babonampoze Marc Bizimana Théogène Bagaragaza Théoneste Kamarampaka Silas

24-26 June 2009: Sensitization and training about agroforestry practices

Zones	Site	Date	Theme	Caracterisation	Nombre des participants	
			Role de la pratique			
Nyamyumba	Kivumu	23.06.2009	Agroforesteriere	Leader opinions		15
Kivumu				Leader Cooperative		2
				Pepinieristes	(29)	
				Autorites locales		14
				Agronomes de Secteurs		2
				Total		33
Kigeyo	Nkora	24.06.2009		Leader opinions		15
Mushonyi				Leader Cooperative		3
				Pepinieristes	(28)	
				Autorites locales		4
				Agronomes de Secteurs		2
				Total		24
Boneza	Bushaka	25.06.2009		Leader opinions		20
Musasa				Leader Cooperative		3
				Pepinieristes	(23)	
				Autorites locales		16
		26.06.2009		Agronomes de Secteurs		2
				Total		41

June 2009: Sensitization and Training on Agroforestry practices:

Date	Zones	Leader opinions		Leader Cooperatives		Local authorities		Ingenior at Sector		Total
24 June 2009	Nyamyumba-Kivumu	M	F	M	F	M	F	M	F	
		14	7	2	2	10	1	1	1	38
25 June 2009	Kigeyo-Mushonyi	12	2	4		4		2		24
26 June 2009	Boneza-Musasa	17	10	2		12	2	1	1	45
Tot		43	19	8	2	26	3	4	2	107

July 2009: 3rd training on the proper conduct and management of nurseries:

Zone	Meeting point	date	Number of participants		Total
			M	F	
Nyamyumba-Kivumu	Rwinyoni	01 July 2009	12	3	15
Kigeyo-Mushonyi	Nkora	02 July 2009	12	3	15
Boneza-Musasa	Kinunu	03 July 2009	6	6	10
Total			28	12	40

Sept. 2009 Meeting with farmers in their respective zones in collaboration of presidents of zones.

Date	Zones	Participation number		Total
29 Sept 2009	Kigeyo	M	F	
		54	43	97
30 Sept 2009	Boneza-Musasa	40	60	100
Total		94	103	197

Summary of trained stakeholders in Rutsiro and Rubavu District, under CAFNET activities. This scheme of training became more efficient progressively, leading to the higher number of trained farmers in Year 3 (table n°1; 2009).

Actor	Target Group	2007	2008	2009
ICRAF	Mayors (District level –total 2)	2*	2*	2*
"	Secretary (Sector -6)	6	4	4
"	Secretary (cell level –total 13)	9	13	29
"	Chef de village (total 75)	60	60	75
"	Agronomist (Sector level –total 6)	6	6	6
	Leader Cooperative – total 11	5	11	10
"	Lead Farmers + Nursery Farmers	25	49 9	62 80
"	Farmers	539	755 (9 meetings)	1452 (16 meetings)
Lead Farmers	Farmers		2500**	3000**

**: Official information only; **: estimated on the base of an average 50 farmers trained by lead farmer*

UGANDA

LIST OF MAIN MEETINGS HELD DURING THE CAFNET PROJECT PERIOD 2007-2011 (NUCAFE)

Sl. NO.	Date	Venue/Country	Event	No. participants
1	21st May 2008	Coffee House, kamapla Uganda	First coordination meeting	7
2	8th Juluy 2008	Coffee House, kamapla Uganda	Coordination meetings	7
3	6th & 7th August 2008	Nkokonjeru and Nakisunga sub counties, Uganda	Value chain and best practice farmer training	104
4	7th October 2008	Coffee House, kamapla Uganda	Coordination meetings	7
5	10th to 13th october 2008	Mpigi district, Bunjako, Buwama, Ggolo sub counties	Value chain and best practice farmer training	452
6	1st August to December 2008	Masaka, Mpigi, luweero and Nakaseke	Training by Business managers on value chain and best practice farmer training	283
7	mai-08	Ntenjeru, Buikwe, Nakifuma	meetings for biodiversity study	76
8	sept-08	Masaka	Training of business managers in groupd dynamics and management of Natural resources	
9	27th November 2008	Coordination meeting	coordination meeting	7
10	8th & 9th october 2009	Jalamaba and Bunjakko	Coordination meetings	8
11	Jan to December 2010	Masaka, Mpigi, luweero and Nakaseke	Value chain and best practice farmer training	200
12	6th April 2010	Masaka	training of 30 TOTs in Market linkage	30
13	Jan to December 2010	Masaka, Mpigi, luweero and Nakaseke	Various farmer trainings from the 10 selected participating members,	2636
14	29th to 31st march 2011	Uganda management institute	Finalisation workshop	18

KENYA

LIST OF MAIN MEETINGS HELD DURING THE CAFNET PROJECT PERIOD 2007-2011 with MUGAMA coffee cooperative union

Sl. NO.	Date	Venue/Country	Event	No. of participants
1	16 November 2008	Barichu Cooperative	Farmers' day; Feed back from M.Montzieux survey	50+
2	28 May 2009	Visite Gichataini Factory	Promotion of goodcoffee processing practices	86 managers from 21 cooperatives
3	March 2010	Visit of Witeithie self help farmers groups; IFRA and ICRAF	Promotion of AF practices; Nursery network organization	100+
4	25 June 2010	Farmers meeting, Muranga	Feed back from Socio economic and agroforestry practices survey; E. Joetzjer & K. Barkaoui	50+
5	23 April 2011	Presentation at the MUGAMA General Assembly	Results and prospects from CAFNET	120+
6	2 September 2011	Presentation at the MUGAMA Board	Results and prospects from CAFNET	20

Bangor University

CAFNET
Final Narrative Report
(January 2007 to September 2011)

Introduction

Bangor University has had a major role in providing training and support for analysing the traditional knowledge gathered by researchers across the research period; the aim being to use context specific and more general local knowledge to inform best practice guidelines, decision support tools and pilot testing. Bangor's involvement consisted of staff travel to CAFNET countries funded from other sources; two research assistants employed to work from Bangor on knowledge bases developed in the project regions and write reports; one software engineer to develop AKT5 software; placement of seven MSc students from Bangor to gather and collate information about impacts on trees on coffee productivity, biodiversity, water and other ecosystem services in Guatemala, India, Uganda, Rwanda and Kenya; and, one PhD student on the joint CATIE-Bangor programme to study coffee agroforestry systems across Nicaragua, Guatemala and Costa Rica. A greater participation than anticipated was achieved, including direct involvement in implementation of the project in Africa and Central America.

This report contains information about the activities that Bangor University has participated in from the beginning of the project in January 2007 to September 2011.

Personnel associated with CAFNET

The Bangor University involvement in CAFNET is through participation of the School of the Environment, Natural Resources and Geography (SENRGY[1]) in the project. The following personnel have been involved in various periods:

1. Dr.Fergus Sinclair: Senior Lecturer (Director of Research until March 2009; agroforestry and local knowledge).
2. Dr.John Healey: Senior Lecturer (Director of Research from 2009 and Reader from 2011; biodiversity)
3. Dr Morag McDonald: Senior Lecturer (watershed management)
4. Dr Rachel Taylor: Research Officer (biodiversity)
5. Mr Jim Doores: Knowledge Engineer.
6. Mr Tim Pagella: Research Assistant (Local knowledge and stakeholder engagement).

[1] Previously known as the School of Environment and Natural Resources (SENR).

7. Ms Genevieve Lamond: Research Assistant (April 2008 – October 2009). MSc International Natural Resource Development student; local knowledge of biodiversity and ecosystem services in smallholder coffee farms in Kenya (June-September 2007).
8. Ms Emma Martin: MSc Environmental Forestry student; local knowledge of biodiversity and ecosystem services in coffee farms in Guatemala (June-September 2007).
9. Ms Carla Barlagne: Research Assistant (May-July 2008).
10. Mr Carlos Cerdan: PhD student on the joint CATIE-Bangor University Doctoral Programme; local knowledge of coffee systems and ecosystem services in Central America (Costa Rica, Nicaragua and Guatemala).
11. Mr Abdullah-Al-Mafuz: MSc Agroforestry student (SUTROFOR); local knowledge of tree pruners in India (May-September 2008).
12. Mr Raju Acharya Sharma: MSc Agroforestry student (SUTROFOR); local knowledge on landscape scale water issues in India (May-September 2008).
13. Ms Anita Hummel: MSc Agroforestry student; local knowledge on biodiversity associated with coffee systems in Uganda (May-September 2008).
14. Ms Lindsey Elliot: MSc Agroforestry student (SUTROFOR): local knowledge of trees on coffee farms in Kenya (May-September 2009).
15. Ms Ruth Nansamba: MSc Agroforestry student (SUTROFOR): local knowledge of trees on coffee farms in Rwanda (May-September 2009).
16. Mr Martin Noponen: PhD student on the joint CATIE-Bangor University Doctoral Programme researching carbon accounting of coffee agroforestry systems in Central America,

Summary of visits to CAFNET countries

While much of the input from Bangor researchers has been through work conducted in Bangor, mainly backstopping knowledge acquisition, development of best practice guidelines and design of decision support tools (see reporting under activity headings below), the travel to participating countries and involvement in work on the ground has been of particular value and much of it has been made possible by travel to these countries for other purposes that has then permitted work on CAFNET to proceed. The following travel to CAFNET partners for collaborative work was completed.

March 2007 Fergus Sinclair visited Nicaragua for meetings with Philippe Vaast, Fabrice de Clerk, Jeremy Haggar and Gabriela Soto including a scoping site visit to the Matagalpa region.

April 2007 Gabriela Soto and Carlos Cerdan from CATIE attended a knowledge acquisition workshop in Bangor together with Emma Martin and Genevieve Lamond.

April/May 2007 Fergus Sinclair visited India to hold a training workshop on knowledge acquisition methods.

May-August 2007 Emma Martin collected local knowledge about biodiversity and ecosystem services on coffee farms in Kenya.

May-August 2007 Genevieve Lamond collected local knowledge about biodiversity and ecosystem services on coffee farms in Kenya.

October-December 2007 Carla Barlagne collected local knowledge about coffee productivity and honey production in coffee farms in india.

May-September 2008 Anita Hummel conducted knowledge acquisition work in Uganda including data collection of tree diversity, habitat provision and phenology.

May-August 2008 Abdulla-Al-Mahfuz collected tree pruners' knowledge about ecosystem services of trees in coffee farms in India.

May-August 2008 Raju Acharya Sharma collected and collated local knowledge and scientific information on rainfall, river flows and sedimentation in India.

October 2008 Fergus Sinclair visited India for the 2nd annual CAFNET workshop.

January/February 2009 Fergus Sinclair visited Costa Rica and Guatemala and interacted with the CAFNET team

March 2009 Fergus Sinclair visited Guatemala and Costa Rica including the feedback workshop for farmers and extension staff in Sierra de las Minas, Guatemala.

From April 2009 onwards Fergus Sinclair began a secondment to ICRAF in Nairobi for 50% of his time allowing regular access to the CAFNET East African regional work and CAFNET students from Bangor based in the region and attendance at the 3rd Annual CAFNET workshop.

May/June 2009 Fergus Sinclair visited India and interacted with the CAFNET team in Bangalore

May-September 2009 Lindsey Elliot conducted work on ranking tree attributes in Kenya.

May-September 2009 Ruth Nansamba conducted knowledge acquisition work in Rwanda.

July 2009 Fergus Sinclair visited Costa Rica for the feedback session on using local knowledge to develop best practice guidelines in Turrialba

August 2009 Genevieve Lamond visited Kenya and while there advised two Bangor MSc students during their research and participated in the 3rd annual CAFNET workshop.

Dr Fergus Sinclair was able to continue to liaise and strengthen the CAFNET programme in East Africa through his role as Global Research Leader in production ecology at ICRAF from April 2009 onwards and effecting liaison with Bangor – he travelled between Bangor and Nairobi frequently as well as visiting Uganda, attended the final East Africa CAFNET workshop in Nairobi in March 2011 and the final Central American CAFNET workshop in Costa Rica in May 2011.

Dr Fergus Sinclair incorporated CAFNET results in high profile presentations at the World Forestry Congress in Buenos Aires (October 2009), the IUFRO (International Union of Forest Research Organisations) World Congress in Seoul (August 2010), the Macaulay Institute in Aberdeen (November 2009) and ICRAF board of trustees meetings in Nairobi (April, 2010 and April 2011).

Dr Fergus Sinclair was in regular Skype contact with Carlos Cerdan (joint CATIE-Bangor PhD student working on CAFNET) and his supervisors at CATIE Dr Bruno Rapidel and Gabriela Soto throughout the project life.

Contributions to CAFNET activities

Activity 1.1 Identification of watersheds and target communities.

In March, 2007 Fergus Sinclair participated in a field visit to select sites with the CATIE CAFNET team to Matagalpa, Nicaragua. During his visit to India in April-May 2007 he participated in a steering committee meeting for the selected watershed in Kodagu and in November 2007 a stakeholder interaction meeting. In Kenya in June 2007 he participated in the initial contact for CAFNET with the farming community in Central Province and Genevieve Lamond subsequently coordinated liaison with political and administrative bodies and the farming community with respect to initial CAFNET work on traditional knowledge, including three feedback sessions to farmer organisations. In Guatemala, Emma Martin made the first contact for CAFNET with the farming community in Sierra de las Minas and developed contacts amongst putative CAFNET collaborators in the region including a presentation to stakeholders in Guatemala city. Fergus Sinclair held discussions with representatives of CATIE, Fundación Defensores de la Naturaleza and Anacafé during his supervisory visit to Guatemala in July 2007.

Activity 1.2 Creation of multi-sector steering committees

Although not scheduled to be involved in this activity, Bangor staff were able to participate in some steering group and other stakeholder meetings (see Activity 1.1 above) by virtue of being in the relevant countries at appropriate times. In Kenya and Guatemala the traditional knowledge work conducted by Bangor personnel represented the initial contact with the farming communities at the target sites and, therefore, helped to establish links with stakeholders in these regions.

Activity 2.1 Documentation of traditional agroforestry knowledge and values of native trees
Bangor University played a major role in providing training and support for the documentation of traditional agroforestry knowledge. During the project period, emphasis shifted from baseline documentation of knowledge to targeted use of farmers' knowledge in understanding how different tree species impact biodiversity (Activity 2.2), water flows across landscapes (Activity 4.2) and can inform management guidelines and associated decision support tools (Activities 2.4, 5.1. and 5.2).

Guides to the knowledge bases from all CAFNET countries (the African guide combines three countries for the East African region), including implications of traditional knowledge for promoting tree diversity on coffee farms. The guides for Costa Rica, Guatemala and Nicaragua are also available in Spanish.

Bangor University provided the AKT knowledge-based systems software used by CAFNET to document traditional knowledge and support has been given continually by email from Bangor to support its use in all regions (Jim Doores, Tim Pagella and Genevieve Lamond). The software was modified to suit the requirements of knowledge acquisition within the CAFNET project (Jim Doores). Supervisory visits were made to Costa Rica, Guatemala, Kenya and India to assist in the acquisition process (see summary of visits above). Bangor personnel (Emma Martin, Genevieve Lamond, Carla Barlagne, Anita Hummel, Abdullah-Al-Mafuz, Raju Acharya Sharma, Lindsey Elliot and Ruth Nansamba) directly conducted documentation of traditional knowledge in Guatemala, Uganda, India, Kenya and Rwanda.

Knowledge bases

Fifteen electronic knowledge bases were developed across the three continents. In India, this was done by researchers from the University of Agricultural Sciences, Bangalore trained by the Bangor team under the leadership of Dr Mohan with assistance from Carla Barlagne and the two masters students who travelled to India mentioned above. In Africa, four Masters students (mentioned above) developed knowledge bases during 2007-09 in Kenya, Uganda and Rwanda, while in Central America, Carlos Cerdan (joint PhD student) developed knowledge bases in Costa Rica, Nicaragua and Guatemala with help from Emma Martin (masters student who pioneered the research in Guatemala). All of the knowledge acquisition was assisted by support from Jim Doores, Genevieve Lamond, Tim Pagella and Fergus Sinclair. The knowledge bases provide a comprehensive and accessible record of traditional knowledge about the effects of trees in coffee plantations on productivity and ecosystem services in Costa Rica, Nicaragua, Guatemala, Uganda, Kenya, Rwanda and Kodagu in India.

Considerable support work was done on merging the three principal Indian knowledge bases (fauna, flora and interactions) and making them, as well as a further four knowledge bases (climate, tree pruner's knowledge, by products and beekeeping), consistent with each other, facilitating analysis and publication of results.

A protocol to collect farmers' ranking of trees for key utility and ecosystem service attributes in Kenya, Uganda and Rwanda was developed and the East African Regional programme of CAFNET at ICRAF employed Genevieve Lamond at 50% time from June 2010 through to April 2011 to achieve this. The resulting data was used as the basis for developing the CAFTREE decision support tool to promote tree diversity on coffee farms.

Farmer knowledge about tree phenology was found to be a rich resource, complementary to that available scientifically, and vital for planning tree diversity to support a rich biodiversity. Phenology data can be incorporated in guidelines for tree selection and decision support tools for designing tree combinations that support biodiversity while meeting farmers' requirements for key products and services.

Activity 2.2 Biodiversity inventories in coffee agroforestry landscapes
Bangor staff (Fergus Sinclair, John Healey and Rachel Taylor) assisted in the design of biodiversity inventory work. Much of this was achieved during the annual CAFNET workshop in September 2007. While in India in November 2007, Fergus Sinclair directly assisted in the planning of the biodiversity inventory and he, John Healey and Rachel Taylor continued to provide advice on sampling and analysis of biodiversity data via email.

A methodology for collecting ranked data on tree attributes was developed and tested by Lindsey Elliott in Kenya during Period 2 and as mentioned above systematic data was collected in Period 4 in all East African CAFNET countries, with tree frequencies from new inventory data, used to structure sampling. The resulting attribute data has been used in developing management guidelines that are sensitive to impacts of different trees and tree combinations for habitat provision.

Activity 2.4 Participatory development and pilot testing of sustainable agroforestry management guidelines

The traditional knowledge documented in Activity 2.1 provides a strong basis for developing management guidelines and, where local knowledge is complementary to scientific understanding, represents a significant resource. Analytical work with the knowledge bases identified tree attributes (e.g. type of shade cast, litter quality and fuelwood quality) critical for designing tree species combinations for sustainable management of coffee systems. Data on these key tree attributes were collected in Kenya, Rwanda and Uganda funded by the East African part of CAFNET but supported by expertise from Bangor. Collated ranked data (has been combined with farmer assessment of tree phenology, and scientific information in the pilot CAFTREE decision support tool. The tool is used to underpin guidelines for selection of trees and tree combinations within coffee farms to meet different sets of production and sustainability objectives, customised for different ecological and socio-economic contexts. This represents a breakthrough in moving away from selecting a few 'best bet' species, towards supporting the maintenance of a diversity of tree species on coffee plots and marshalling the information that is needed to promote the trees (e.g. propagation or pruning management protocols) where it is needed. The collection and analysis of ranked data on tree attributes by farmers required development and testing of novel methods (Figure 1). These and the CAFTREE pilot decision support tool have been adopted by ICRAF, not only for use in coffee agroforestry, but also as a model for incorporating traditional knowledge more generally in promoting tree diversity on farms.

Plate 1. Farmers ranking tree attributes in Mukono district, Uganda.

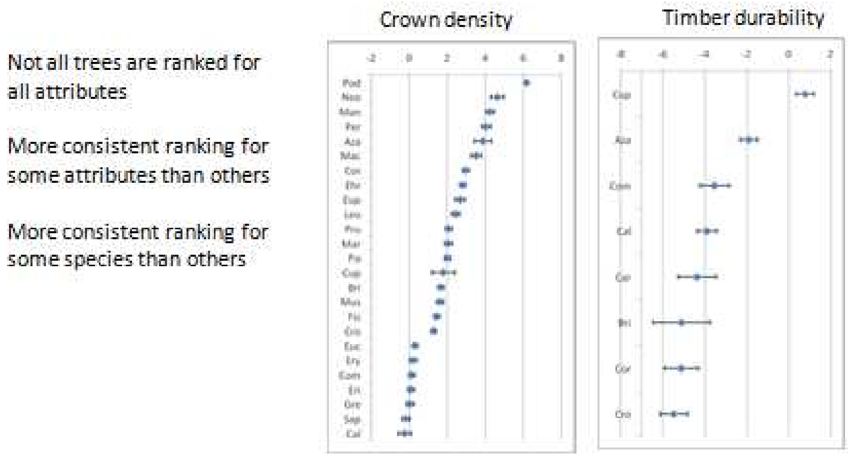


Figure 1. Analysed farmer ranking of trees for crown density and timber durability in Kenya (tree species code on y-axis, species whose error bars do not overlap are significantly different), showing key features of the data obtained. Around 30 species were ranked for around ten attributes in each of three countries using a survey design where farmers only ranked species that they were familiar with. Greater detail is given in the East Africa CAFNET report.

The information held within knowledge bases about farmers understanding of the impact of trees on coffee productivity and ecosystem services, has permitted comparisons across CAFNET countries and regions to look at where the differences and similarities lie. This has and will continue to inform the design of management guidelines both in terms of the content of the guidelines and in designing appropriate language and means to convey them to stakeholders.

Tool development

The AKT software tools were modified in response to the initial documentation of traditional knowledge within CAFNET. Four high level tools now exist for the following tasks:

1. exploring interactions amongst components (e.g. trees and pests)
2. tabulating attributes of components (e.g. attributes of shade trees in coffee farms)
3. comparing how components are locally classified (see Figure 1), and
4. comparing information on particular topics amongst different knowledge bases.

These four high level tools use a further five re-useable lower level tools to produce output that is directly relevant to CAFNET project objectives. The nine new tools were developed by Jim Doores from specifications provided by Tim Pagella, Genevieve Lamond and Fergus Sinclair for use within the CAFNET project. These tools are now incorporated in the AKT software and can be downloaded from the AKT website together with the knowledge bases, guidebooks and dissertations from each of the CAFNET countries and regions.

The AKT5 software tools have further been modified in response to the merging of the Indian knowledge bases. This work has been carried out by Jim Doores from specifications provided by Genevieve Lamond for use within the CAFNET project. The system tools 'merge_External_Statements' and 'merge_formal_terms' have been deleted and replaced by the single tool 'merge_knowledge_bases'. This tool has been introduced to give more flexibility when merging knowledge bases and to enable the merging of object hierarchies and tools using strict criteria.

The layout of the tools in AKT was revamped and made more user-friendly by breaking ‘System Tools’ down into smaller sections according to their applicability (multiple/single KB analysis and consistency tools). The latest AKT5 version is available to all CAFNET partners and other interested parties via the AKT website (AKT.bangor.ac.uk).

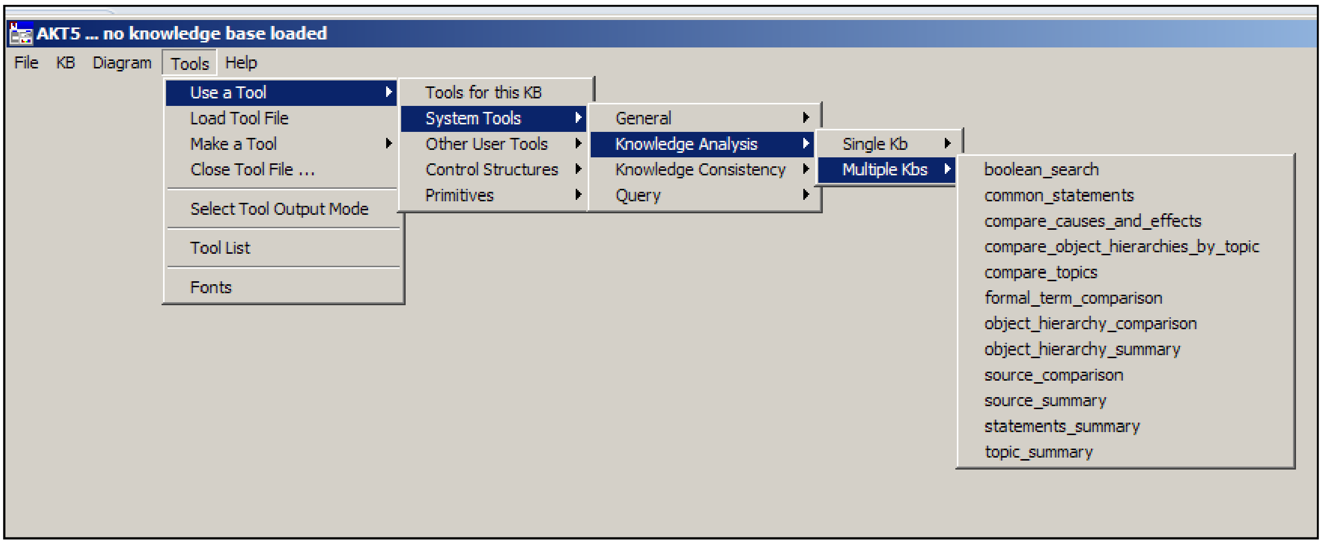


Figure 2. New tool layout.

CAFTREE

CAFTREE is a pilot decision support tool for promoting tree diversity on coffee farms (Figure 3). It combines local knowledge and scientific data and expertise to suggest tree species assemblages for coffee farms, customised to local circumstances in East Africa. Initially the tool has been developed specifically for use in the CAFNET study areas in three African countries but the approach has been adopted by ICRAF for further development and testing. Jim Doores produced the tool to specifications developed by Fergus Sinclair and Genevieve Lamond that incorporate expertise and tree databases from ICRAF (particularly Sammy Carsen and Caleb Orwa).

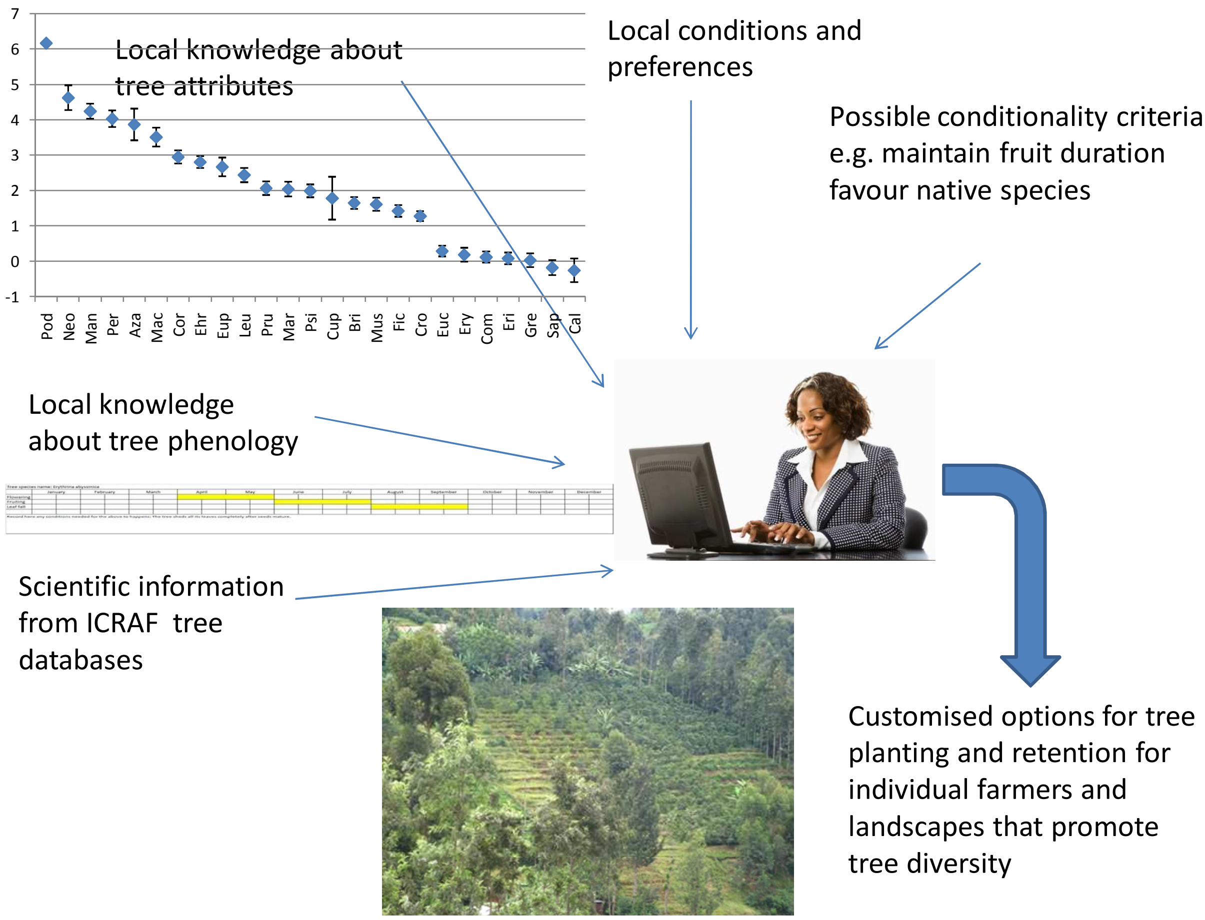


Figure 3. Schematic view of the CAFTREE decision support tool,

Activity 4.2 Watershed and landscape integration and monitoring of impact

Advice on modelling and visualisation of water flows at landscape scales was provided by Fergus Sinclair during visits to Africa, India and Central America. The Polyscape GIS toolkit for exploring synergies and trade-offs amongst impacts of tree cover on hydrology, habitat provision and productivity developed in Bangor were demonstrated and discussed with CAFNET partners.

Activity 5.1 Building capacity of organisations to manage sustainable coffee agroforests and to participate effectively in improved marketing of coffee and tree products

The stakeholder engagement involved in the knowledge acquisition and development of management guidelines has contributed to capacity strengthening of organisations, not least by invigorating participation. In all regions strengthening of capacity to include local perspectives in planning and implementation of management guidelines has been achieved and accessible resources for sustainable coffee management provided in the form of knowledge bases, guides and summary reports based upon them.

A5.2 Dissemination of methods and lessons to national and regional actors

A key element of the methodology used for acquiring and using traditional knowledge in development involves feedback sessions with farmers and other stakeholders. All of the Bangor PhD and MSc students under the CAFNET project conducted feedback sessions to farmers in Guatemala, Nicaragua, Costa Rica, Kenya, Uganda, Rwanda and India. Fergus Sinclair took part in a stakeholder interaction meeting in India in November 2007. Reports of knowledge acquisition and associated knowledge bases in Guatemala and Kenya have been mounted on the AKT5 webpage. In Central America, Carlos Cerdan, Gabi Soto and Fergus Sinclair presented findings to farmers and other stakeholders in Guatemala, Nicaragua and Costa Rica in the first half of 2009, using guides developed for this purpose.

Dr Fergus Sinclair incorporated CAFNET results in high profile presentations at the World Forestry Congress in Buenos Aires (October 2009), the Macaulay Institute in Aberdeen (November 2009) and the ICRAF board of trustees meetings in Nairobi (April, 2010 and April 2011). A presentation on comparative analysis of local knowledge about ecosystem services of trees in coffee systems was given by Fergus Sinclair at the IUFRO World Congress in August 2010.

Plate 2. Students acquiring knowledge as part of AKT training

A broad range of international young professionals on the EU Erasmus Mundus SUTROFOR and SUFONAMA MSc courses at Bangor (over 50 participants over the project period) were given basic training in knowledge acquisition using CAFNET examples. An intensive training course was held with 26 students between 2007 and 2010 who learnt how to use the methodology fully and applied it in various natural resource management domains in project work in the CAFNET research sites, as well as other projects in Ethiopia, Mali, Tanzania, Ghana and Zambia.

Martin Nopenen, a PhD student on the CATIE-Bangor joint doctoral programme (supervised by Dr John Healey), who has developed carbon accounting methods for coffee agroforestry systems in Nicaragua and Costa Rica, prepared a presentation delivered by Jeremy Haggar at the final CAFNET meeting in Costa Rica in May, 2011.

UW Bangor has created a specific webpage (http://akt.bangor.ac.uk/ProjectDownloads.php) where student theses, guidelines for farmers' interviews, data collection and to using CAFNET knowledge databases are freely accessible.

.

Outputs

Cerdan, C. R., Rebolledo, M.C., Soto, G., Rapidel, B. and Sinclair F.L. (in revision). Local knowledge about ecosystem services of trees in coffee farms in Costa Rica. *Agricultural Systems* (in revision).

Cerdan, C.; Lamond, G.; Pagella, T.; Soto, G. and Sinclair, F.L. (2009). Local knowledge of coffee productivity and ecosystem services in coffee plantations surrounding Macizo Pena Blancas Reserve, Jinotega-Matagalpa Departments, Nicaragua: A guide to using the CAFNET-Nicaragua knowledge base.

Cerdan, C.; Martin, E.; Lamond, G.; Pagella, T.; Soto, G. and Sinclair, F.L. (2009). Local knowledge of coffee productivity, biodiversity and ecosystem services in coffee plantations in El Hato Watershed, Guatemala: A guide to using the CAFNET-Guatemala knowledge base.

Cerdán, C.; Rebolledo, C.; Martin, E.; Soto, G.; Lamond, G.; Pagella, T and Sinclair, F.L. (2008) Local knowledge on coffee productivity, biodiversity and ecosystem services in coffee plantations in Central America: A guide to using the agro-ecological knowledge toolkit (AKT5). Report produced for the 2nd annual CAFNET workshop held in India, October 2008.

Cerdán, C.; Soto, G.; Martin, E.; Rebolledo, C.; Rapidel, B. and Sinclair, F.L. (2008) Comparative analysis of farmers' knowledge about ecosystem services and coffee productivity across Central America. World Congress of Agroforestry 2009, Book of abstracts, p212. [oral presentation with powerpoint slides]

Barlagne, C.and Sinclair F.L. Coffee quality and management practices in Kodagu, Karnataka, South India. School of Environment Natural Resources and Geography, Bangor University, UK Report.

Elliot, L. (2009) Farmers' perceptions about the utilities of trees associated with coffee farms in Central Province, Kenya. MSc Thesis, Bangor University.

Hummel, A. (2008). Local knowledge on ecological interactions in shaded coffee agro-ecosystems surrounding Mabira Forest Reserve, Uganda. MSc Thesis, Bangor University.

Hummel, A. (2011). Informed by practice. Film produced from footage taken during MSc research. ICRAF and Bangor University.

Hummel, A. (2011). Coffee farming in Mukono district, Uganda (*draft title*). Film produced from footage taken during MSc research. ICRAF and Bangor University.

Lamond, G. (2007). Local knowledge of biodiversity and ecosystem services in smallholder coffee farms in Central Province, Kenya. MSc Thesis, Bangor University.

Lamond, G. (2009). Overview of local knowledge research. Presentation at the 3rd CAFNET annual workshop, Kenya, August 2009. Powerpoint slides.

Lamond G. and Leguet, J-B. (2007). Presentation on feedback sessions held with farmers in Central Province, Kenya. Presentation to CAFNET group at ICRAF, Nairobi, July 2007, PowerPoint slides.

Lamond, G.; Muiru, N.; Gathoni, E.; Bernadeau, G.; Hummel, A.; Pagella, T. and Sinclair, F.L. (2008) Local knowledge of biodiversity and environmental services in coffee farming systems in East Africa: A guide to using the agro-ecological knowledge toolkit (AKT5). Report produced for the 2nd annual CAFNET workshop held in India, October 2008.

Lamond, G., Sinclair, F.L., Gassner, A., Smith, E. and Omeli, M. (2011) Consistency of farmer knowledge about tree attributes in coffee agroforest systems: A comparative study in Kenya, Uganda and Rwanda. Presentation at the final CAFNET workshop, Kenya, March 2011. Powerpoint slides.

Martin, E. (2007). Local knowledge of biodiversity and water conservation in the coffee farming landscape of Guatemala.MSc Thesis, Bangor University.

Martin, E. (2007). El conocimiento de los cafetaleros sobre la biodiversidad y los servicios ambientales dentro de sus cafetales: investigacion realizó en la subcuenca Río Hato, San Agustín Acasaguastlán, El Progreso. Presentation to stakeholders, Guatemala, July 2007, Powerpoint slides.

Mohan, G.S.; Mahfuz, A.; Lamond, G.; Pagella, T. and Sinclair, F.L. (2008) Local knowledge of biodiversity and environmental services in coffee agroforestry systems in the Western Ghats, India: A guide to using the CAFNET-India knowledge bases. Report produced for the 2nd annual CAFNET workshop held in India, October 2008.

Mahfuz, A. (2008). Local knowledge of tree pruners about biodiversity associated with coffee agroforestry systems in Kodagu District of India. MSc Thesis, Bangor University.

Nansamba, R. (2009). Local knowledge about trees and ecosystem services in coffee plantations in Rubavu and Rutsiro Districts, Rwanda. MSc Thesis, Bangor University.

Nopenen, M and Attarzadeh, N. (2011). La Huella de Carbono. Presentation at the final CAFNET workshop, Costa Rica, May 2011 (oral presentation and powerpojnt slides).

Sharma, R.A. (2008). Local knowledge of the effects of climate change on water regimes within coffee agroforestry systems in the Western Ghats, India. MSc Thesis, Bangor University.

Sinclair, F.L. (2007). Progress with local knowledge in the CAFNET project. Presentation at the CAFNET first annual workshop, CATIE, Costa Rica, September, 2007, Powerpoint slides.

Sinclair, F.L., Lamond, G., Pagella, T.F., Cerdan, C., Mohan, G.D Systematic approaches to combining local and scientific knowledge about ecosystem services of trees. Oral presentation at IUFRO World Congress, Seoul, South Korea 23-27th August, 2010. Powerpoint slides abstract published in *The International Forestry Review* 12 (5): 474 .

Sinclair F.L. The future of timber is on farm? A global prognosis for timber supply from farm land. World Forestry Congress, Buenos Aires, October, 2009. Powerpoint presentation.

Sinclair F.L. A tree for all reasons: tools for negotiating where to have trees in agricultural landscapes. Invited Seminar, Macaulay Institute, Aberdeen, November, 2009. Powerpoint presentation.

Sinclair, F.L., Kalinganire, A., Sileshi, W.S., Mowo, J., Degrande, A., Joshi, L., Singh, P. and Porro, R. Improving productivity of farming systems with trees: GRP2 outlook. World Agroforestry Centre, Board of Trustees Meeting, April 2010. Powerpoint presentation.

Sinclair, F.L., Kalinganire, A., Barrios, E., Muthuri, C., Radcliffe, A,, Sileshi, W.S., Mowo, J., Degrande, A., Pradhan, U., Singh, P, Porro, R, Lamond, G. and Gassner A. (2011). How trees can improve the productivity of farming systems: GRP2 outlook. World Agroforestry Centre, Board of Trustees Meeting, April 2011. Powerpoint presentation.

Sinclair, F.L., Doores, J., Lamond, G., Pagella, T., Carsan, S.and Orwa, C. (2011), Developing a decision support tool for promoting tree diversity in coffee agroforest systems. Presentation to the final East Africa CAFNET workshop, Nairobi, Kenya, March 2011. Powerpoint presentation.

Sinclair, F.L., Doores, J., Lamond, G., Pagella, T., Gassner, A., Carsan, S.and Orwa, C. (2011), Developing a decision support tool for promoting tree diversity in coffee agroforest systems. Presentation to the final CAFNET workshop, Turriabla, Costa Rica, May 2011. Powerpoint presentation.